MIDDLE EAST WATERSHED MONITORING AND EVALUATION PROJECT
PASA # PCE-P-00-01-00011-00
ANNUAL REPORT for 2004

September 15, 2005

Section I. Technical Progress

This is the fourth Annual report of the Middle East Watershed Monitoring and Evaluation Project for the year 2004. All technical and financial reporting is coincident with the annual cycle of the project as outlined in the May 29, 2001 guidance. Additionally, this report details further research efforts by project participants that compliment the USAID/MERC-funded initiatives through financial support by the USDA Forest Service and the U.S. Department of State.

1. <u>Research Objectives:</u>

    a. Specific Project Objectives:
        i. Monitor and evaluate the effectiveness of watershed management practices in preventing erosion and increasing the efficiency of water use in arid and semi-arid watershed pilot programs,
            - Monitor the effects of these practices through measurement of vegetation, hydrology, and erosion and sedimentation data,
            - Evaluate the monitoring tools used to assess treatment effectiveness,

        ii. Evaluate the biophysical measurements appropriate for evaluation of operational watershed management practices implemented for erosion control and biomass production in arid and semi-arid regions,
        iii. Demonstrate effective practices for forest and grassland management using pilot watershed programs.

    b. Specific Objectives for Year Four:
        i. Continue the ongoing monitoring program underway in all participating countries,
        ii. In the West Bank, begin monitoring at the fourth site, Zeif, which was previously inaccessible due to the political situation in the area,
        iii. Hold a fourth International Study Team (IST) workshop,
        iv. Conduct trainings between West Bank and Israeli partners.

2. <u>Research Accomplishments:</u>
    Each country collected numerous data points at their study sites. Analysis of this data as well as relevant conclusions with regard to project objectives will be addressed in the final project report.

a. Israel
    i. Fifteen rainfall events were measured in non-forested, newly forested, and forested sites,
    ii. A detailed sample of biomass and biodiversity was taken from the study site for further examination in reference to micro-topographic effects on biomass production and species richness,
b. Jordan
    i. Detailed data concerning rainfall and runoff amounts was collected at the study site and five gauging stations,
    ii. An inventory of the vegetative cover of the study site was conducted through graduate student research efforts,
c. Turkey
    i. Measured total catchments sediment flow levels on a regular basis, but only recorded one runoff event in the three sub-catchments,
    ii. Percent cover of species and biomass measurements were taken from three sub-catchments.
d. United States
    i. Rainfall, soil moisture and sediment production from roads were measured in the Upper South Platte watershed,
    ii. Measurements were taken on 20 thinned and 20 control swales with regard to changes in ground cover.
e. West Bank
    i. Additional water harvesting structures were established at each of the three existing sites,
    ii. Fruit trees, medicinal plants, and herbs were planted at each of the three existing sites.

3. <u>Scientific Impact of Cooperation:</u>

   Collaboration between participants increased significantly from prior years:

   - Israel and Turkey incorporated silt fences into their study sites, after witnessing their effectiveness during the 2004 IST study tour in Colorado,
   - Jordan installed stream gauges identical to those being utilized in Israel,
   - Israel has fashioned evapo-transpiration plots after examples seen in the U.S. during the 2004 IST study tour,
   - The West Bank team incorporated research techniques related to study plot design that are similar to those employed by Turkey, the U.S. and Israel,
   - Graduate students from the West Bank traveled to Israel for two separate training events that were developed specifically for them by the Israeli study team. The training workshops were focused on remote sensing, soil moisture analysis, and vegetation classification,
   - A graduate student from the West Bank traveled to Jordan, met with the Jordanian study team, visited their study site design and made determinations about the most effective way to measure the impact of water harvesting on natural vegetation attributes.

4. Description of Project Impact:

   While it is too early to provide an assessment of the project's impact, there are three notable positive impacts:

   - Improved collaboration and cooperation between country teams,
   - Growing interest by local landowners and land managers in the studies, particularly with regard to soil conservation and regeneration of native plants. Several farmers near the West Bank site and in Jordan have implemented changes in their management practices based on what they have observed on the MERC sites. By the elimination of grazing on certain study plots, land owners have observed benefits that include regeneration of native and palatable plants, decreased erosion and sedimentation, and greater water efficiency,
   - Further research opportunities have developed for graduate students whose work was sponsored through this program.

5. Strengthening of Middle Eastern Institutions:

   a. Graduate Students whose research was or is supported through this project:
      i. Israel: 5 (4 MS & 1PhD),
      ii. Jordan: 8,
      iii. United States: 4,
      iv. West Bank: 5.

   b. In Jordan, there is great institutional support for the MERC project in both Al Balqaa University and in the Royal Scientific Society's Badia Research Program. The lead project researcher at Al Balqaa was promoted to become a vice-president of the University, after being promoted to become a dean of the University. He now oversees a wider array of research programs and initiatives related to watershed management and applied ecological research. As a result, other University researchers, Badia Program researchers and former graduate students have advanced and assumed a greater role in the project management and implementation,
   c. Project partners have visited the U.S. to participate in USFS-sponsored seminars and study tours related to watershed management,
   d. Research institutions associated with this program have secured funding from outside agencies to finance additional initiatives related to watershed monitoring that build on the MERC project. An example of this includes the Tal Rimmah Study in Jordan,
   e. As in other years, the annual IST workshop and other exchanges have led to capacity building among participants,
   f. Partners in Israel and the West Bank are engaged in dialogue to continue training exchanges for graduate students.

Section II

1. Managerial Issues:
   a. In 2004 the management of this project was transferred from the International Monitoring Institute in Fort Collins, CO, to the Forest Service's International Programs (IP) office based in Washington, DC. An unexpected and positive result of this transition is the increased role of participants in project implementation. Over the last year, IP has overseen the project on an administrative level, and has coordinated appropriate technical consultation by current and retired technical experts from the USFS. IP has witnessed participants assuming a more active role in the ongoing development and implementation of the program,
   b. Year Five MERC funding has been dispersed and the final IST workshop is scheduled to take place in Cyprus from October 1-3, 2005. The most recent budget sheets for all 5 participating countries reflecting all sources of funds are appended to this report.

2. Special Concerns:
   - Previously, the West Bank study team had been unable to access their study site at Zeif. They are now able to access the site with some regularity, and have begun to implement the establishment of plots as they had initially intended. Additionally, through support from the Israeli study team and the USFS, the West Bank team was able to secure permits to visit Israel for two training activities at Ben Gurion and the Blaustein Institute. The first few attempts by the West Bank graduate students to use their permits were unsuccessful. After repeated attempts and long periods waiting at the border, the team was finally able to cross into Israel. Their second visit was a slightly easier border crossing. Political tensions are still reported to be high in the West Bank, rendering the students unable to share their experience in Israel with others at home,
   - The international study team hopes to come to a resolution about what type of future training is both feasible and beneficial for the West Bank and Israel. In the last week, the West Bank has proposed another short course for its students in Israel. The proposal is attached.

3. Cooperation, Travel, Training, and Publications:
   - In July of 2004, IST members traveled to Colorado for the fourth annual IST workshop,
   - Five students from Hebron University in the West Bank have participated in two specialized training workshops at Ben Gurion University and the Desert Research Center,
   - Two graduate students (one in Jordan and one in the West Bank) completed their final research efforts in support of their theses which are not yet published,
   - The following document was published: Libohova, Z., *Effects of Thinning and a Wildfire on Sediment Production Rates, Channel*

Morphology, and Water Quality in the Upper South Platte River Watershed, Fort Collins, Colorado, Spring 2004,

- Details on further exchanges between the West Bank and Israel can be referenced in the attached document,
- See attached documents regarding the 2005 IST workshop in Cyprus.

4. Request for USAID actions:

   There is no request for USAID action at this time.

5. Attachments:
   - Financial Spreadsheets up to 2004,
   - 2004 country reports,
   - Agenda and participant list from the Cyprus meeting,
   - Request from the West Bank for further training in Israel.

Monitoring and Evaluating Afforestation in a Semiarid Watershed (Yatir Region, Israel)

Annual Scientific Report

1 January 2004 – 31 December 2004

under the

Middle East Watershed Monitoring and Evaluation Project

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Soil conservation and water regulation - watershed scale

Research team

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Objective

Within the purpose of this research a careful, scientific comparison is undertaken to determine the output of runoff and erosion from a 'natural' watershed, from an afforested watershed and from a watershed that has undergone intensive land management. The objective of this research effort is to determine first-ever the effects of afforestation and land management without afforestation on the runoff and erosional responses of a semiarid terrain.

The objective includes comparison between these three types of land use for given rainstorms and the relative and absolute effects of rainstorms of varying intensity, duration and frequency on the runoff and sediment yield responses. Because the intensive land management activities have recently been completed, the managed terrain is not yet in dynamic equilibrium. Hence, we shall also determine the temporal variation of its effect; i.e., to evaluate the time required for such a terrain to acquire stability. Although the primary objective of this research is to compare outputs, we shall also attempt to identify the main sources of erosion.

Research Watersheds

The Nahal (wash or wadi in Hebrew) Bikhra Watershed was chosen because of its location in a semiarid environment, and because it includes a newly afforested, unforested and treated areas. The untreated areas are not natural in the sense that this part of the world has been grazed, often overgrazed, for the past 3,000 years. We intend to monitor the entire Bikhra watershed (18.5 Km^2). In the meantime we have monitored 3 sub watersheds (Fig. 1): an afforested watershed (1.6 km^2) mostly covered by pine, an unforested watershed (0.6 km^2) and a newly afforested watershed (2.1 km^2). The newly afforested watershed also incorporates the unforested watershed, such that by subtracting the unforested from the newly afforested, we shall determine the response of the newly afforested watershed excluding the headwaters. The extent of treatment was large, such that undesired effects such as bank instability appeared at some locations.

Methods

Rainfall on the watersheds is represented by 16 miniature rainfall gages (magaz in Hebrew). Their location is shown in Figure 2. Three rainfall recorders have been deployed to determine rainfall intensity, possibly one of the most important variables in determining runoff response.

We have constructed 2 Parshall Flumes: each can handle as much as 15 $m^3 s^{-1}$. These allow accurate determination of water discharge at the outlet of the newly afforested and the unforested watersheds (Fig. 4). The forested channel was dammed to form a small pond, and a stage staff monitors its maximal water depth. Because this watershed was expected to yield little, if any runoff, recording instrumentation was diverted to the other watersheds. The depth of flow at the weir edge determines water discharge by a depth transducer, a depth sensor that transmits the depth of water to a built-in data logger.

Sediment is being monitored by three separate means. At the outlet of the newly afforested and the unforested watersheds, we have installed pump samplers at each of the Parshall flumes. Theses are automatic ISCO 24-bottle samplers. Beside each of the end pipes through which water is being siphoned in to the samplers, we have installed a turbidity sensor to determine the continuous turbidity of the water. Sedimentation plates have been installed within the small pond draining the entire afforested watershed.. These will allow determination of sedimentation volumes on a single-event basis.

Rainfall Data

During the 4th year of this research effort, we monitored altogether 15 rainfall events (Table 1). Most of the depths were low (< 20 mm), surpassing 20 mm in 5 of the events. Combining Table 2 with Figure 2, we conclude that there are relatively large differences between the rainfall depth measured at the forest as opposed to the unforested and newly forested basin. High rainfall intensity is a very significant variable in generating runoff. The two rainfall recorders in the Bikhra watershed allow analysis of rain maximal rainfall intensities for different periods of time as displayed in Table3.s due to topography.

Table 1. Rainfall depth (mm) at miniature rain gages during 2004.

Event no.	Event Date	Small Rain Gage Number														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	7-9/1/04	15	14	18	17	*	15	16	20	12	21	*	21	16	15	15
2	12-14/1/04	47	49	55	59	*	56	38	63	*	86	*	84	*	61	46
3	22/01/04	5	4	4	6	*	6	4	5	3	6	*	6	*	4	5
4	27/1/04	4	4	4	5	*	5	3	4	4	5	*	6	*	5	5
5	1-2/2/04	*	20	23	23	*	23	18	20	19	23	*	20	*	20	20
6	14-15/2/04	9	9	10	11		7	6	10	6	11		10		8	7
7	21-22/2/04	7	8		7	6	6	5	10	6	6	5	5	6	5	5
8	6/3/04	10	12	13	13	12	12	12	14	11	*	13	13	11	11	12
9	20/3/04	1	2	1	2	1	3	2	3	2		1	1	2	2	3
10	28-29/10/04	14	2	*				18	13		11	14	11			
11	17-18/11/04	*	27	*	*	*	22	*	24	21	26	30	26	26	25	21
12	21-22/11/04	44	50	60	63	60	53	50	67	53	55	63	62	55	53	50
13	26-27/11/04	11	15	19	20	15	18	15	22	18	19	19	21	18	17	17
14	7-8/12/04	17	21	20	21	21	18	19	22	19	26	29	34	20	22	19
15	15-16/12/04	5														
16	24-26/12/04	16	16	15	*	*	*	15	15	14	17	18	19	17	17	15

* No data as a result of vandalism, physical damage, theft of gages and gages blocked by sand or dust.

Table 2. Area average storm rainfall depth for the different sub-watersheds.

Rainfall depth (mm)				
Event Number	Event Date	Unforested	Newly Forested	Forested
1	7-9/1/04	15	13	21
2	12-14/1/04	59	52	85
3	22/01/04	5	5	6
4	27/1/04	5	4	6
5	1-2/2/04	22	20	22
6	14-15/2/04	8	8	11
7	21-22/2/04	6	7	5
8	6/3/04	11	12	13
9	20/3/04	2	2	1
10	28-29/10/04	(14)	16	12
11	17-18/11/04	24	22	27
12	21-22/11/04	54	57	60
13	26-27/11/04	18	18	20
14	7-8/12/04	20	20	30
15	15-16/12/04	5	5	10
16	24-26/12/04	17	15	18
Annual Rainfall (mm)		290	276	377

Table3. Maximal rain intensities for different durations recorded at rainfall recorder B located in the unforested watershed.

Event #	Date of event	5 min		10 min		15 min		20 min		25 min		30 min	
		A	B	A	B	A	B	A	B	A	B	A	B
1	7-9/1/04	*											
2	12-14/1/04	*	26.2	*	23.7	*	17.5	*	14.6	*	13.2	*	12.2
3	22/01/04	*											
4	27/1/04	*											
5	1-2/2/04	*											
6	14-15/2/04	*											
7	21-22/2/04	*											
8	6/3/04	*											
9	20/3/04	*											
10	28-29/10/04	*											
11	17-18/11/04	*											
12	21-22/11/04	*											
13	26-27/11/04	*											
14	7-8/12/04	*											
15	15-16/12/04	*											
16	24-26/12/04	*											

* No data as a result of vandalism, physical damage, theft of gages etc.

Flow and Runoff Data

During 2004 flow data has been collected at the three hydrometric stations. Tables 4-6 summarize water discharge, which was low in comparison with other years.

Table 4: Summary of flow data for the forested sub-watershed.

Event Number	Event Date	Start Time
1	7-9/1/04	No flow
2	12-14/1/04	No flow
3	22/01/04	No flow
4	27/1/04	No flow
5	1-2/2/04	No flow
6	14-15/2/04	No flow
7	21-22/2/04	No flow
8	6/3/04	No flow
9	20/3/04	No flow
10	28-29/10/04	No flow
11	17-18/11/04	No flow
12	21-22/11/04	No flow
13	26-27/11/04	No flow
14	7-8/12/04	No flow
15	15-16/12/04	No flow
16	24-26/12/04	No flow

As in former years with a single exception, water flow was not generated out of the forested watershed, although rainfall depths were considerable, as much as 87 mm during November 17-22, 2004.

Table 5. Flow data summary for the unforested sub-watershed. The highest water flow events were in November, likely due to high rainstorm intensities.

Event Number	Event Date	Start Time	End Time	Duration hh:mm	Maximal Discharge m^3/sec	Flow Volume m^3
1	7-9/1/04	No flow				
2	12-14/1/04	13/01/04 14:59	14/01/04 10:31	8:26	0.13	970
3	22/01/04	No flow				
4	27/1/04	No flow				
5	1-2/2/04	No flow				
6	14-15/2/04	No flow				
7	21-22/2/04	No flow				
8	6/3/04	No flow				
9	20/3/04	No flow				
10	28-29/10/04	No flow				
11	17-18/11/04	18/11/04 05:12	18/11/04 05:36	00:24	2.21	1040
12	21-22/11/04	No Data				
13	26-27/11/04	No Data				
14	7-8/12/04	No Data				
15	15-16/12/04	No Data				
16	24-26/12/04	25/12/04		01:07	0.06	32

Table 6. Flow data summary for the newly afforested sub-watershed.

Event Number	Event Date	Start Time	End Time	Duration hh:mm	Maximal Discharge m^3/sec	Flow Volume m^3
1	7-9/1/04	No flow				
2	12-14/1/04	13/01/04 15:21	14/01/04 14:33	14:00	0.13	2263
3	22/01/04	No flow				
4	27/1/04	No flow				
5	1-2/2/04	No flow				
6	14-15/2/04	No flow				
7	21-22/2/04	No flow				
8	6/3/04	No flow				
9	20/3/04	No flow				
10	28-29/10/04	No flow				
11	17-18/11/04	17/11/04 21:37	18/11/04 10:20	02:40	1.65	2300
12	21-22/11/04	22/11/04 08:30	22/11/04 20:20	7:04	1.37	7850
13	26-27/11/04	No flow				
14	7-8/12/04	No flow				
15	15-16/12/04	No flow				
16	24-26/12/04	25/12/04 17:38	25/12/04 19:41	2:03	0.01	29.5

Water discharge during 12-14January 2004 was low, although rainfall depth was 59 mm, likely due to low rainfall intensities.

Notes: Duration of water flow excludes intermissions during flow events; Data not available as the equipment in the hydrometric station was stolen or vandalized.

Table 7: Summary of rainfall and runoff data in the monitored watersheds for the year 2004.

Event No.	Event Date	Average rain depth mm			Runoff mm			Runoff coefficient %			Specific discharge $m^3\ s^{-1}\ km^{-2}$		
		F	U	N	F	U	N	F	U	N	F	U	N[@]
1	7-9/1/04	21	15	13	No flow			No flow			No flow		
2	12-14/1/04	85	59	52	*	1.47	1.02	*	2.49	1.96	*	0.196	0.059
3	22/01/04	6	5	5	No flow			No flow			No flow		
4	27/1/04	6	5	4	No flow			No flow			No flow		
5	1-2/2/04	22	22	20	No flow			No flow			No flow		
6	14-15/2/04	11	8	8	No flow			No flow			No flow		
7	21-22/2/04	5	6	7	No flow			No flow			No flow		
8	6/3/04	13	11	12	No flow			No flow			No flow		
9	20/3/04	1	2	2	No flow			No flow			No flow		
10	28-29/10/04	12	14	16	No flow			No flow			No flow		
11	17-18/11/04	27	24	22	*	1.57	1.04	*	6.5	4.7	*	3.35	0.75
12	21-22/11/04	60	54	57	*	*	3.56	*	*	6.2	*	*	0.62
13	26-27/11/04	20	18	18	No flow			No flow			No flow		
14	7-8/12/04	30	20	20	No flow			No flow			No flow		
15	15-16/12/04	10	5	5	No flow			No flow			No flow		
16	24-26/12/04	18	17	15	*	*	0.013	*	*	0.09	*	0.0045	*

- Watershed names: **F** = Forested, **U** = Unforested, **N** = Newly forested.
- N.F. - no flow.
* no data
[@] Calculation of the specific water yield from the newly afforested area is inaccurate because it depends not only on the difference in runoff between the unforested and newly afforested sites, but also on transmission losses between them

The data in Table 6 is insufficient to reach conclusions concerning rainfall/runoff ratios, since the events measured are low to very low, and the quality of the flow data is poor.

Soil Erosion

One of the purposes of this project is to examine the sources and monitoring means of the soil erosion in the monitored area. Soil erosion derives from hillslopes and wadis. This can be examined by a variety of methods from which we have selected the following:

1. Creating a silt fence on hillslopes to capture eroded sediment (on a slope area of approximately 500 m^2).
2. Placing sedimentation plates in small Limans draining microwatersheds (2000-5000 m^2).

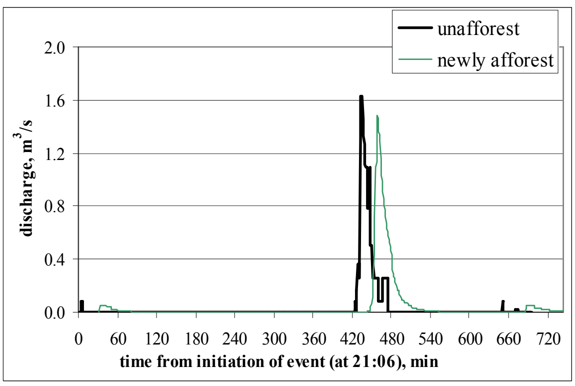
3. Measuring the advance of gully heads on small hillslope areas (approximately 1000 m^2).
4. Cross sectional measurements of the wadi changes. The changes in width and depth of the cross sections indicate of the quantity of eroded and deposited sediment.
5. Monitoring sediment concentration at the hydrometric stations by deployment of automatic (ISCO) 24-bottle samplers and calibrated turbidometers.

Since there were no significant flow events this year, sediment could not be collected by methods 1-4. The ISCO and turbidity methods did operate for short periods of time during low flows; maximum monitored concentration was 50,000 mg/l, though typical concentrations were somewhat low for this semiarid, loess clad area. Methods 1-4 will be implemented at the end of the 5-year period of this project unless a large event occurs earlier. Method 5 was deployed during several events. This section describes the detailed runoff, sediment concentrations and water quality (electrical conductivity of the water denoted by EC) of individual events this winter.

The first considerable rainfall event on 17-18 November, 2004 generated flood hydrographs in the two basins that show the lag in and the diminished runoff from the newly afforested basin (Fig. 1a). Water quality was high (low EC values) in both basins (Fig 1b, 1c), with a slight flushing effect at the beginning of the hydrograph (beginning of winter).

Unlike the low dissolved solids concentrations, those of suspended sediment were similarly elevated in both basins (Fig 1c). Such concentrations have been typical during the previous years; apparently although runoff yield is considerably decreased, as is therefore sediment yield from the newly afforested area, the concentration of sediment remains high 4 years after planting, likely due to the rigorous machinery changes which the basin underwent.

Figure 1a. Hydrographs during the 17-18 November 2004 events.



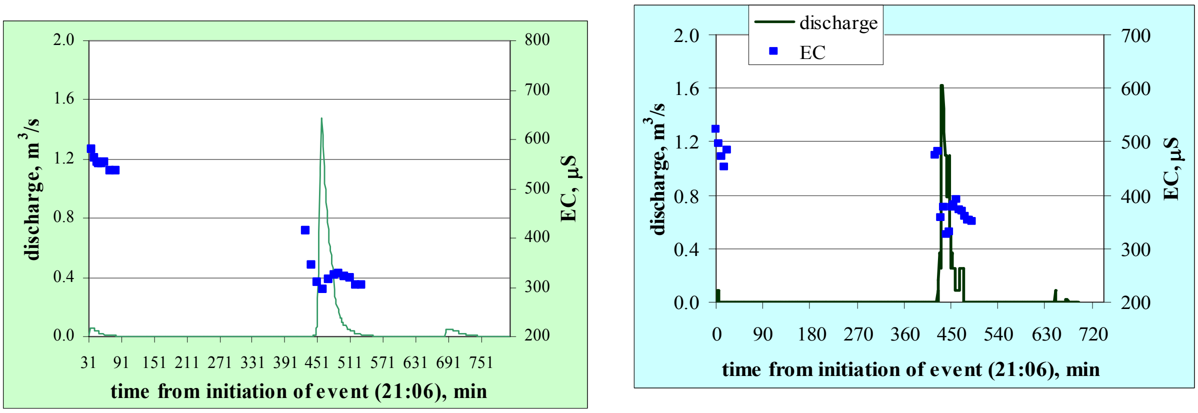


Figure 1b. Hydrograph and EC during the 17-18 Nov 2004 event, newly afforested (left) and unforested (right) basins.

Figure 1c. Hydrographs and sedigraphs during the 17-18 Nov 2004 event, newly afforested (left) and unforested (right) basins**.**

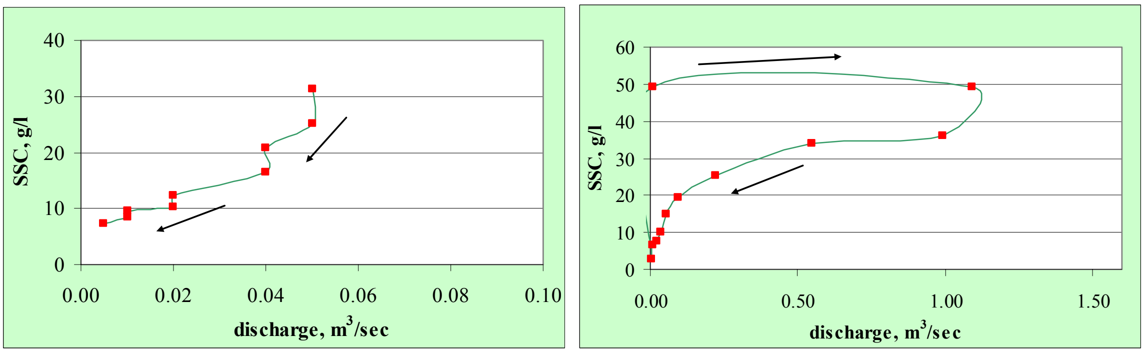


Figure 1d. Variation of suspended sediment concentration (SSC) with discharge (Q) during the 17-18 Nov 2004 event in the unforested basin.

Table 8. Sediment concentrations and sediment yield from the unforested and newly afforested basins in the 2 significant flow events of this winter.

	sed yield ton		median SSC g/l		max/min event SSC g/l	
event	un	nf	un	nf	un	nf
17-18 Nov 04	2.13	68.9	17.66	8.43	58.81/5.32	49.21/2.62
25 Dec 04	0.38		8.41		17.57/1.85	

* according to water samples or **according to turbidity values
SSC - suspended sediment concentration
nd – no data; un –unforested; nf – newly afforested

The high concentration of sediment, indicative of a high erosion rate, directly depends on water discharge, but is particularly high by flushing when discharge is higher (Fig. 1d). On November 22 we monitored only in the newly afforested basin due to instrumentation problems at the upper gauging station (Fig 2). A comparison may be made in the hydrologic response of the two basins for the December 8 event: the hydrograph peaks differ more and the lag is somewhat shorter that those for the November 17-18 event (Fig 1a). Water samples were unavailable for this event.

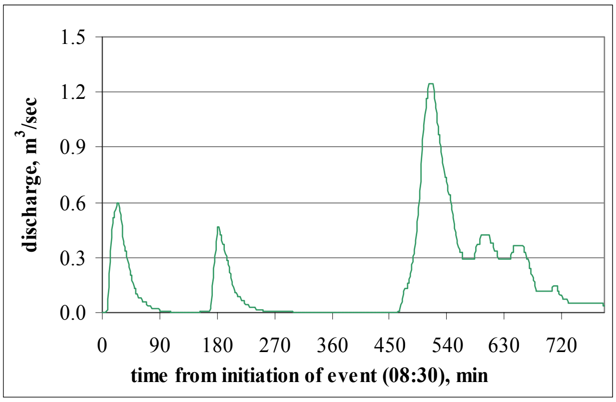


Figure 2. Hydrograph during the 22 Nov 2004. Data from the unforested basin are unavailable.

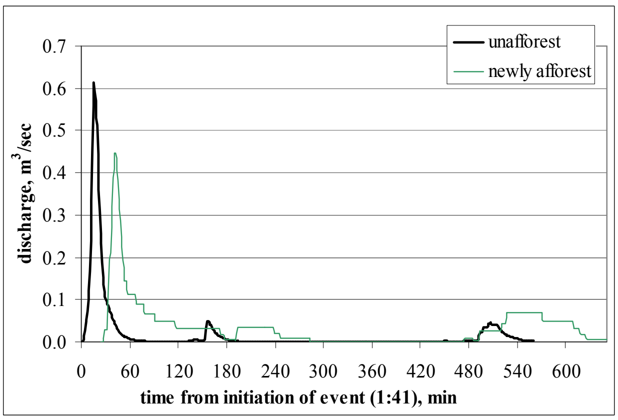


Figure 3. Hydrographs during the 8 December 2004 events.

An additional comparison between hydrographs is illustrated for the 25 December event (Fig 4a). Discharge was very low from the unforested basin and negligible from the newly afforested basin. During this event water quality was excellent (very low EC values) and sediment concentrations were also low (Fig 4b).

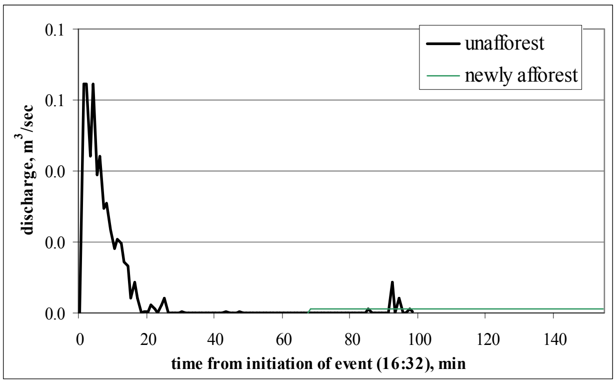


Figure 4a. Hydrographs during the 25 Dec 2004 event.

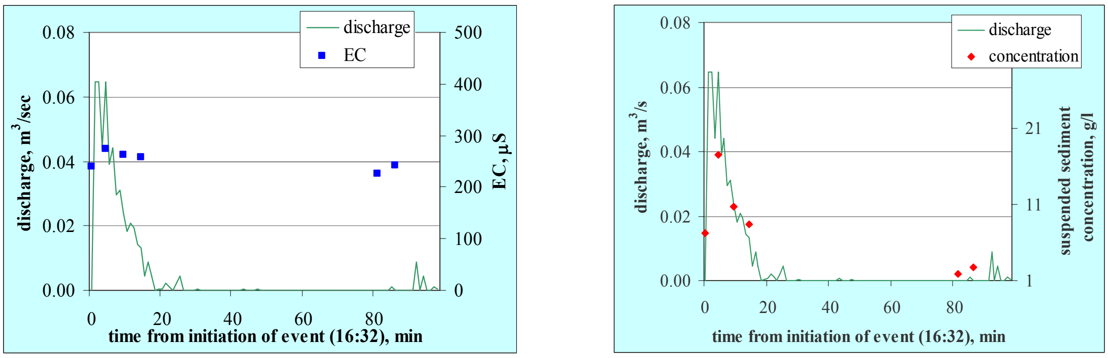


Figure 4b. Hydrographs and sedigraphs during the 17-18 Nov 2004 event, newly afforested (left) and unforested (right) basins.

Mechanisms of water conservation – local scale

Research team

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Objective

Observations carried out during the present project indicate that the Yatir forest is instrumental in the regional water conservation by dramatically reducing runoff. The objectives of the activities described below are to study the mechanisms of water regulation effected by the trees on a small scale which lead to overall water conservation. This was accomplished by assessing the various components of the water balance of the trees in the afforested area and in the nearby clearing by: evaluating the influence of tree canopy interception on the amount and distribution of rain beneath tree canopies; examining the influence of the canopy on the rainfall/runoff relationship; estimating the relative importance of each component in the water balance equation for the Yatir Forest, and comparing changes in total soil water content in the afforested area and in the nearby clearing.

Methods

Two monitoring systems were established, one inside the forest and one in a clearing located close by, each with three plots of $70m^2$ each. In each of the plots located inside the forest there were 3-5 trees. In each of the plots the following relevant parameters have been continuously measured since October 2000:

Precipitation was monitored (a) in the forest with a recording rain gauge above the canopy, (b) in the forest below the canopy (20 cans) in each of the three replicates, and (c) in the open plots with a standard rain gauge and 2 non-standard rain gauges.
Tree stem flow was monitored on six trees (located outside the instrumented plots). A collar installed at a height of 1 m above ground collected the water running along the trunk and conveyed it to a plastic container.

Surface runoff was monitored within the forest using a specially designed and built tipping bucket with a resolution of 1 l s^{-1}, which was installed at the outlet of each of the three plots. In the clearing runoff was monitored on one plot using a tipping bucket and measuring the total runoff in the remaining two.

Soil water content was monitored with a neutron probe in weekly intervals to a depth of 6 meters, in each plot (inside the forest 2 plots with 7 access tubes each and outside the forest one plot with 3 tubes and one tube in each of the remaining two plots).

Tree transpiration estimated by monitoring the sap flow velocity with the heat pulse technique on six trees (five of them located within the boundaries of one of the plots) was monitored up to the summer of 2003. Due to sensor breakdown and lack of replacements this aspect was discontinued. In the present report we detail the rainfall and moisture measurements carried out during the 2003/2004 season.

Results

Moisture measurements: During the 2003/4 season water content measurements were carried out within the forest and in the clearing. Seasonal course of readings for the various monitored depths for one typical access tube within the forested area are presented in Fig. 1. It appears that no changes in water content could are apparent below a depth of 1.5 m. This pattern is similar to what has been observed in previous years. We decided to objectively determine this depth by comparing the Coefficient of variation (CV=St. Dev./mean) for the whole season for each depth to the CV of the standard of the instrument (CV_{st}). The rationale being that for those depths for which the CV was similar to the CV of the standard no changes in water content occurred and those depths could be ignored for total soil water content computation. Their inclusion causes noise that probably would mask small systematic changes. Results are presented in Fig. 2. All tubes reach the critical value CV_{st} at a depth of 1.65, which corresponds with the first reading taken within the rocky layer. Tube No. 6 exhibits a larger CV than the other tubes for almost all depths. We attribute these changes to the fact that this access tube was located in the lower part of the plot within a depression, thus probably receiving the runoff generated above it. The reason for the small increase in the CV observed at ca. 3 m. is presently being analyzed.

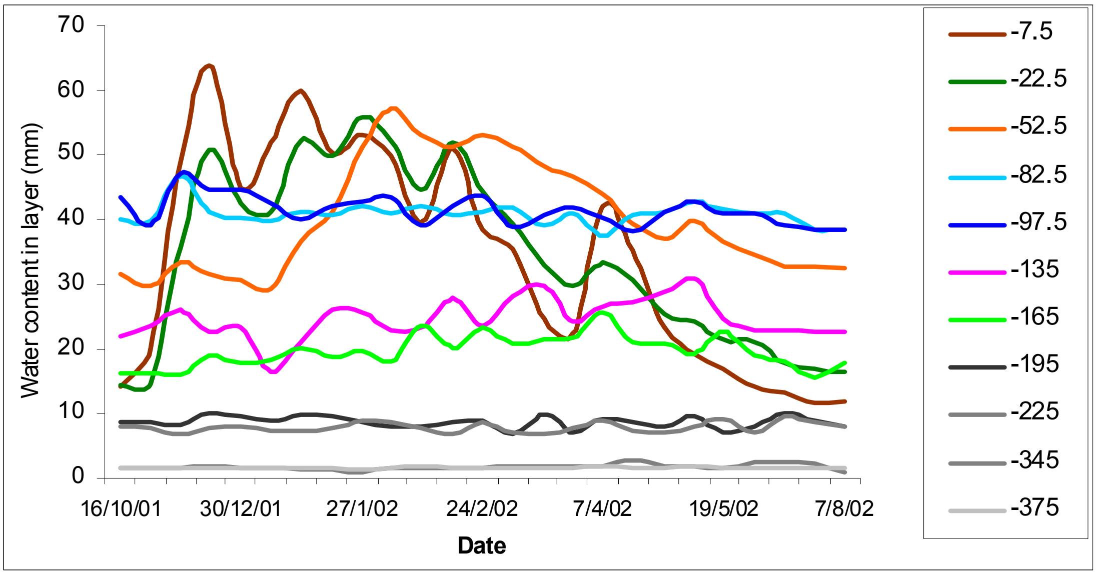


Fig. No 1. Typical change in the water content for the various layers (depths in cm. indicated in the box on the right) for tube No. 3.

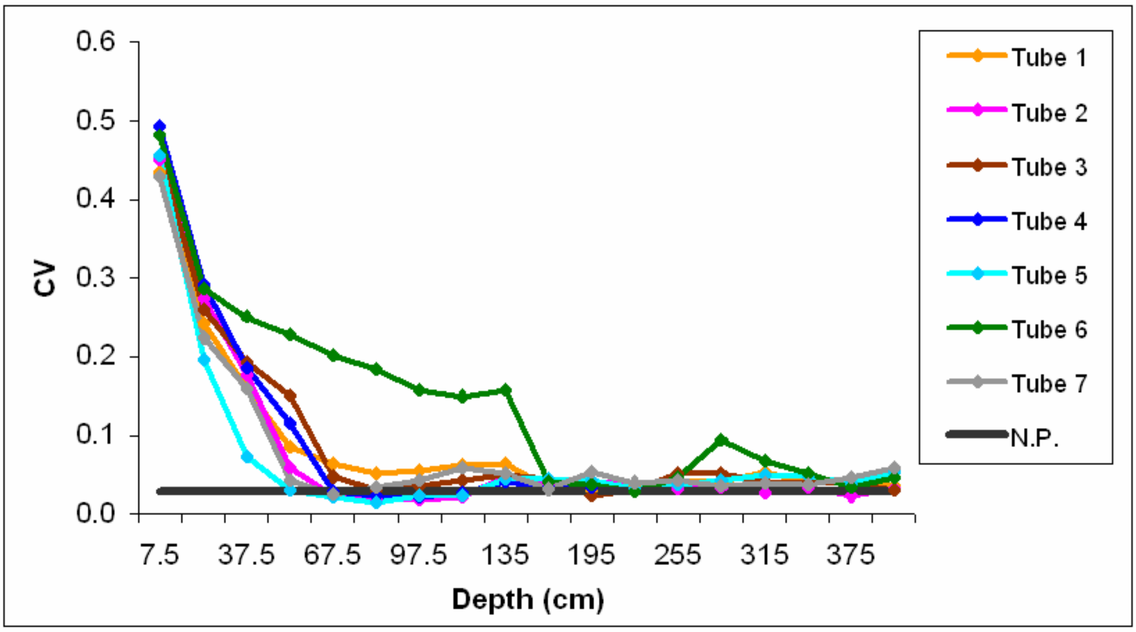
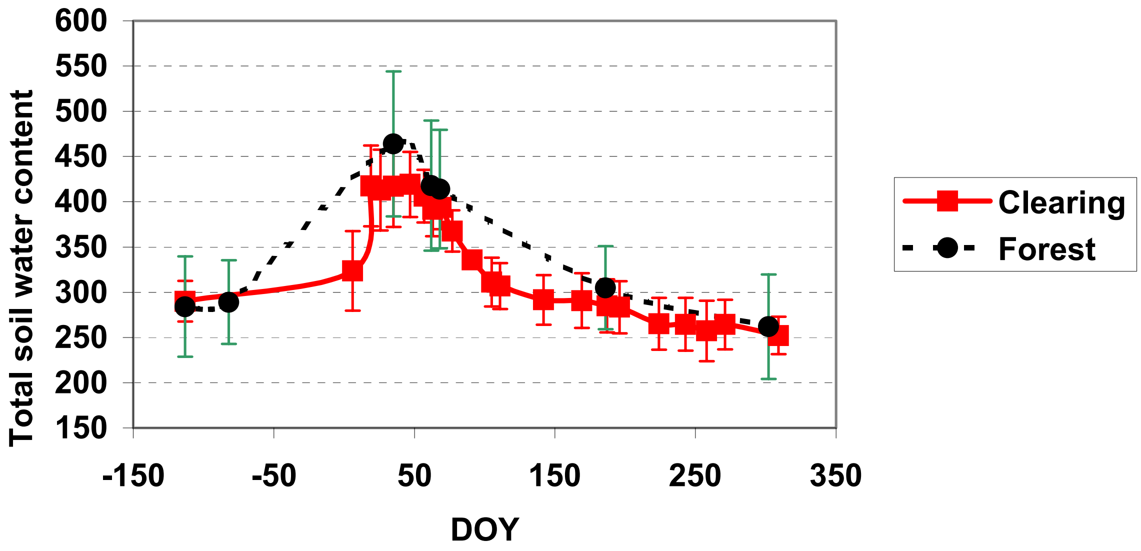


Fig. No.2. Coefficient of variation for the various tubes within the forested area as a function of depth.

We carried out similar analysis for the clearing and the maximum depth was as well determined. The total water content to the thus determined depth was computed and the average results for both sites during the 2003/4 presented in Fig. 3. The general trend is similar to the one observed for previous seasons and no significant difference between the sites (clearing and forested) was evident prior to the onset of the rainy season nor at the end of the 2004 summer.

Fig 3. Changes in the total soil water content (mm) during the 2003/4 season at both sites (clearing and forest). Bars denote one standard deviation. DOY 0 corresponds to the 1.1.04.



The total amount of water left in the profile at the end of the 2004 summer (DOY 300) is however less than at the end of the previous summer (DOY –80). This result contrasts with positive values found for previous seasons and which are summarized in Table 1.

Site	FOREST			CLEARING		
Season	2001-2002	2002-2003	2003-2004	2001-2002	2002-2003	2003-2004
Water source	Throughfall+Stemflow-Runoff			Rain-Runoff		
Net water input	276.3	307.4	195.3	298.5 (12)	328.0 (13)	209.8 (5.3)
Storage (mm)	3.5 (9.7)	19 (21.7)	-22 (5.7)	18.1	13.5 (24.3)	-33.3 (24.2)
Water use (mm)	272.8 (9.7)	298.9 (21.7)	223 (5.7)	280.4 (12)	314.1 (36.5)	243.2 (22.7)

Table 1. Major components of the local water balance at the two adjacent studies sites (forested and clearing) in the Yatir Forest during three consecutive seasons. Numbers in parenthesis are the corresponding Stand. Dev. (no values are presented for Net water input [Forest] as runoff data for only one instrumented plot was recorded for all seasons). Storage was computed as the change in the total soil water content between measurements carried out before the onset of two rainy consecutive seasons and the water use as the difference between net water input and water use.

The Net water input is systematically higher in the clearing than in the forest, even though the differences are very small. No significant differences between clearing and forested area are evident neither in the storage nor in the water use for the three seasons. The noteworthy fact is that

during the last reported year negative storage values were observed for both sites and the suggestive fact that for both sites the negative value of the storage is balanced by the sum of the previous two seasons
Overall the results presented in the table suggest that the presence of the forest has not changed the annual water balance. The fact that the plots in the clearing were not grazed may have wider implications for the management of areas similar to this one.

Supporting biodiversity – vegetation monitoring

Research team

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Scientific background

Organisms living in arid and semiarid regions are confronted by a common problem of water shortage. It is caused by both low rainfall and unpredictable distribution of rainfall during the growth season (Hill and Woodland 2003, Prinz et.al. 1999). Water catchments have been used for thousands of years to solve these problems. They are designed to store runoff from relatively large contributing slope areas into smaller areas that enjoy increased water availabilities. Such relatively simple practices allow human habitation and cultivation of agricultural cops in arid zones (Hillel 1997).

In Yatir, the KKL started the afforestation project in the 1960s'. The main tree species was Aleppo pine, an introduced species that is very common in north Israel. The afforestation practice involved planting of trees on naturally-shaped slopes with very little or no alteration of the topography. Recently, KKL initiated an alternative afforestation system whereby a relatively large variety of non-coniferous trees are planted along runoff boosted contour trenches that take advantage of the hilly topography of the region (Safriel, et al. 2002). Contour trenches are constructed by bulldozing long stripes of surface soil from contributing areas to construct elongated trenches and mounds perpendicularly to the slope. Such a modified topography allows for greater (x 3-5) water availability along the dammed trenches where the trees are planted. Consequently, the modified topography is comprised of a diversity of micro-topographies that are not very common in unmodified landscape, such as exposed rock surfaces (that were skimmed from surface soil, swales and soil mounds as well as patches of unmodified slopes (Figure 1). There are quite large differences in the physical characteristics of these micro-topographies. For instance, while the mound and the swale have relatively deep soil, there is very sallow soil in disturbed patches. Microtopography also affects soil water content due to changes in the ratio between runoff donor and receptor areas as well as soil depth. In mounds, the deep soil can e.g. hold more runoff water that is filtrated from the swale; hence more water is available for its vegetation. Swales are also potential sinks for organic matter and nutrients. These large edaphic differences suggest that contour topography is expected to generate a patchwork of habitats that best suit different groups of plants (and other organisms). For example, while the more mesic swale and mound base are expected to harbor more mesic Mediterranean plants, the more exposed, soil-poor, disturbed micro-habitats are expected to be more suitable for competitively weak, slow-growing, xeric desert plants.

Since the initial topographical modification of the contours includes a drastic removal of most of the existing vegetation, the contour habitat as a whole is initially open for colonization and succession. These processes depend on the local biotic and abiotic factors, such as light level, temperature, water availability, competition, individual species traits, etc.

Previous research in Yatir (e.g. 2003 report) demonstrated that the total number of species found in the Yatir's Aleppo pine forest was slightly lower than that of non-afforested areas. Nevertheless, there was a large difference in species composition between forested and natural open areas. Among 122 identified species found in both areas, 27 were new to the local natural plant community, probably due to the unique physical conditions created by the pine forest (Ariza 2003). It is expect that contour afforestation may have also created new types of habitats and an increased spatial heterogeneity that would allow, at least in the long run, the coexistence of an increased number of plant species, community types and biodiversity. The goal of the current research was to study this general hypothesis, figure out the possible ecological and conservational implications of contour afforestation in Yatir and develop an efficient vegetation monitoring scheme that would allow for testing these implications in the long run.

Objectives

Analyze the 2003 and 2004 contour and untreated control vegetation data.
Study the effects of microtopography and slope aspect on biomass production and diversity of natural vegetation.

Methods

Experimental design
The micro-topography of the contour habitat and slope aspect (East and West) were considered as main factors. Eight sites were selected according to slope aspect and habitat type (Table 1):

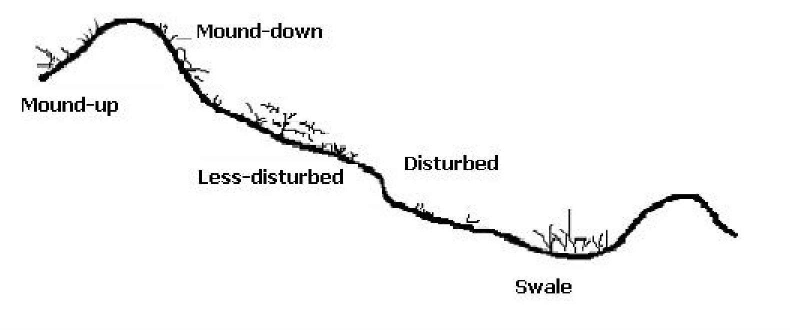
Table 1: Survey design

Slope aspect	Habitat	# plots
East	Control (unmodified slope)	2
East	Treatment	2
West	Control	2
West	Treatment	2
Total		8

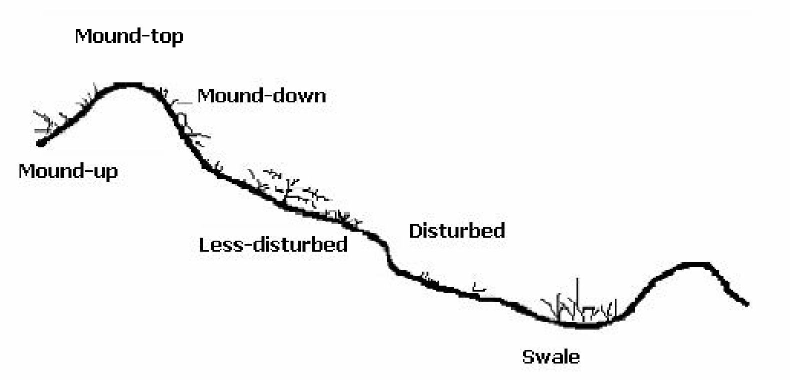
Table 2: Coordinates of the plots

Aspect	Treatment	Plot 1	Plot 2
East	Control	31°18'12" N, 35°00'28" E	31°18'06" N, 35°00'48" E
East	Treatment	31°18'09" N, 35°00'16" E	31°18'10" N, 35°00'47" E
West	Control	31°18'04" N, 35°00'35" E	31°18'05" N, 35°00'55" E
West	Treatment	31°18'14" N, 35°00'16" E	31°18'04" N, 35°00'36" E

In 2003, the contour habitat was divided into 5 micro-habitats according to topography and extent of disturbance. In 2004 one micro-topography (mound-top) was added (Fig 1).



2003



2004

Figure 1: Micro-habitats across a single contour trench in the 2003 and 2004 surveys.

Plant biomass and diversity

Harvest of aboveground vegetation in the studies plots was conducted in the end of March of 2003 and 2004, when the vegetation was at peak mass production and bloom. The harvest included shrubs in 2003 but not in 2004. In 2003 we used transects; in each site two transects were set perpendicularly to the contour and across all micro-habitats. The width of transects were 10 cm and the length varied depending on the length of the contour. In control sites (untreated slope), the length of the transect varied from 3 to 21 m. The plants were collected by species and micro-topography along each transect and were bagged for further processing. Plant samples were frozen until further processing and than identified and weighted after drying for 48 h at 70 ºC in a ventilated oven. In 2004 plants were samples in 20 X 30 cm quadrates. The quadrates were randomly locatred within each micro-habitat. The total quadrate array is detailed in Figure 2:

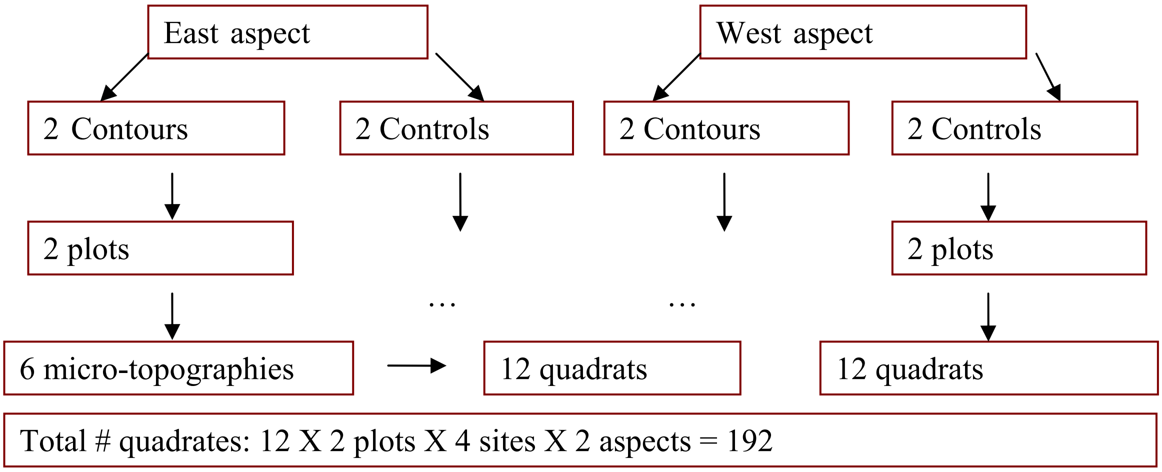


Figure 2: Vegetation quadrate sampling in the 2004 survey.

In 2004, the sampling was interrupted due to military restrictions and only half of the control plots were sampled. Thus, the final number of surveyed quadrates was 192-12*4= 144.

Biomass, species richness and evenness

Biomass per sq. m, species richness per quadrate and Shannon's evenness index were calculated for the 2003 and 2004 data. Since section size varied among plots in the 2003 transect data, species richness was translated into species richness per quadrate (0.06 sq.m) so the 2003 and 2004 could be compared.

Data analyses

Statistical analyses (multifactor ANOVAs, comparison of means, regressions) were conducted using STATISTICA 7. Factors included slope aspect (East, West) and micro-topography. Significance level was set to $\alpha = 0.05$ for all tests.

Results

Species-Area curves

Species-area curves were made based on the 2003 data. The curves (Figure 3) indicate that the appropriate minimal sample size should be larger than 0.4 sq. m to best represent the species richness in the studies habitats.

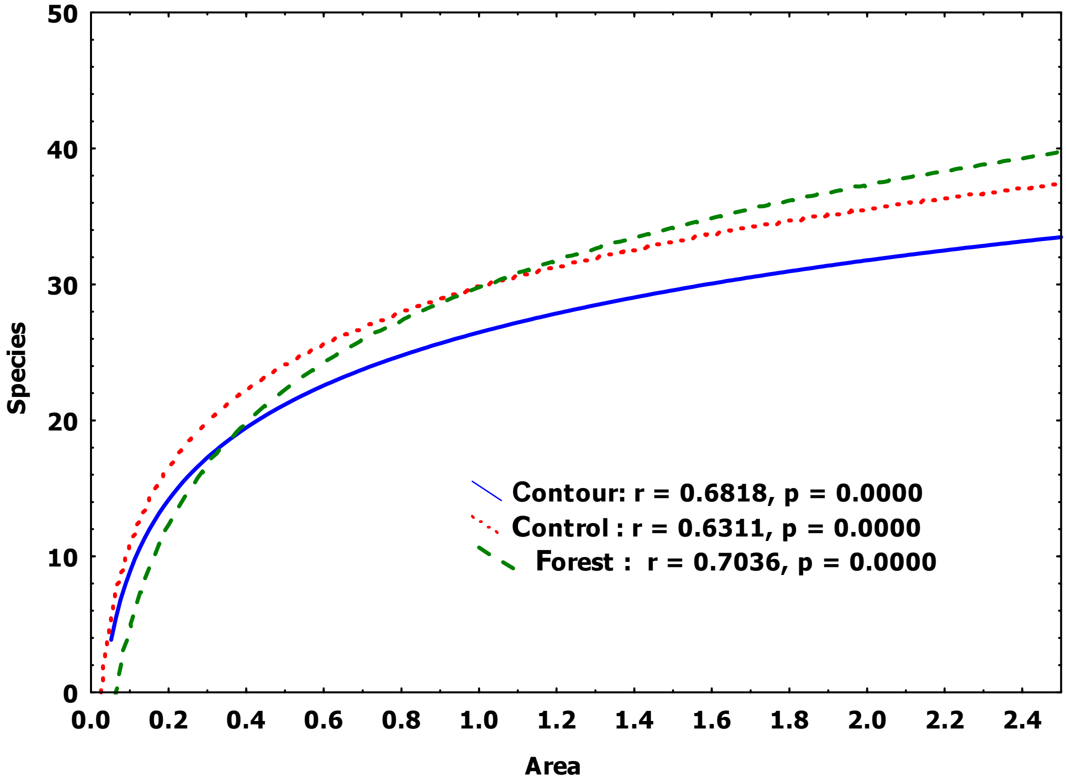


Figure 3: Species-Area curves in 2003

Plant biomass

Factorial analysis of the 2003 data shows there was no significant effect of aspect on total plant biomass (F (1, 207) = 0.0142, p = 0.905). The effect of micro-topography on biomass was not very significant either (F (5, 207) = 1.57, p=0.17). However, using one way ANOVAs, showed some significant differences among specific micro-habitats (F (4, 121) = 3.21, p=0.015), with the disturbed micro-topography being least productive (figure 4).

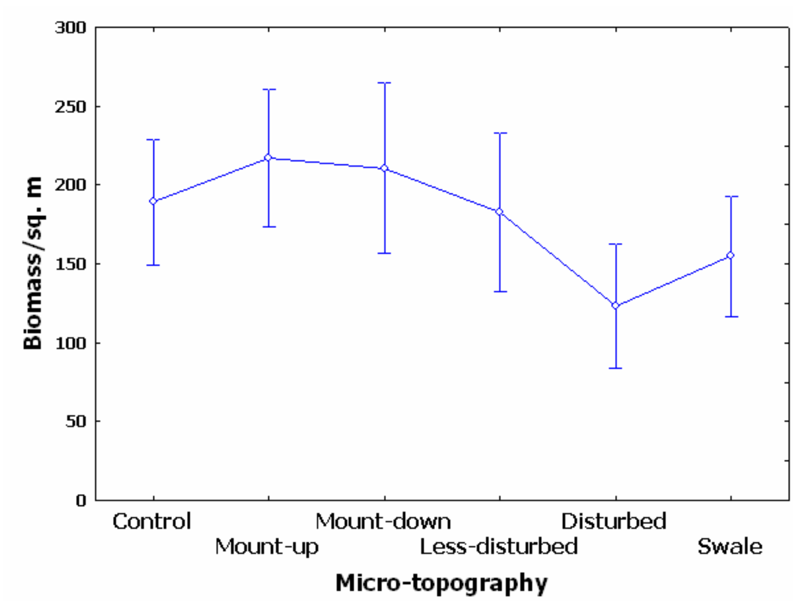


Figure 4. Biomass production by micro-habitat in 2003

The analysis of the 2004 data showed no significant effect of slope aspect on mass production (F (1, 130) = 1.137, p= 0.288), but a significant difference among control and contour sites (F (6,130) = 3.884, p=0.001); (Figure 5).

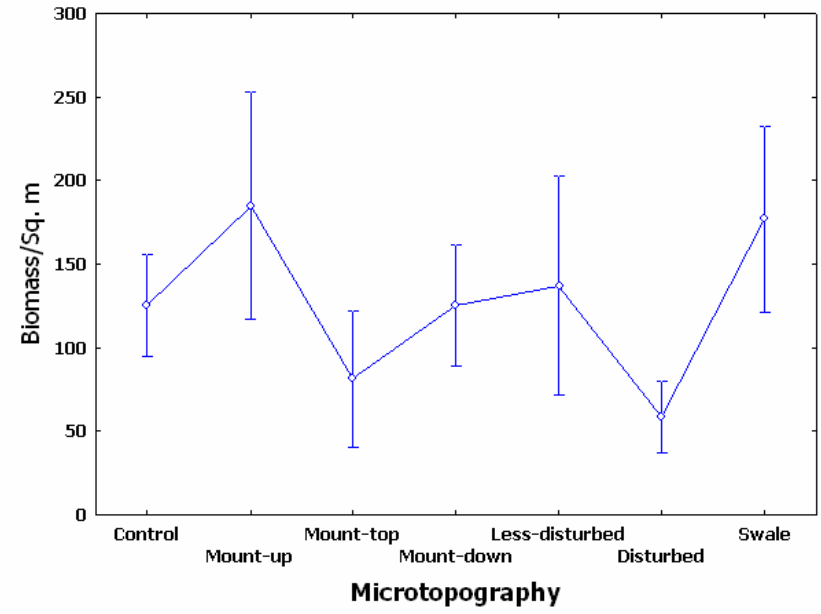


Figure 5: Biomass production by micro-habitat in 2004.

Besides the disturbed micro-topography, biomass production in all of the other miro-habitats recovered quite well following the initial disturbance associated with the construction of the contours. The 2004 data demonstrated an increased average biomass in swales compared to control sites. Taking the entire contour as a single habitat, there were no significant differences in biomass production between the control and the contour sites in both 2003 and 2004 (Figure 6).

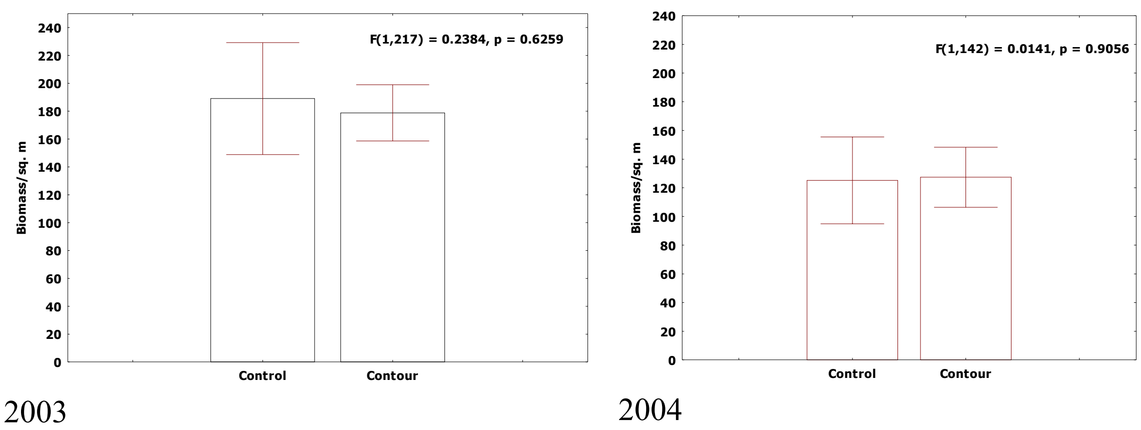


Figure 6: Biomass production in control and contour sites in 2003 and 2004.

Species richness

Both the 2003 and 2004 data showed significant effects of micro-topography and no effects of slope aspect on species richness (Table 3).

Table 3: The effects of slope aspect and micro-topography on species richness

	Factor	F	p
2003	Aspect	0.0000	0.996
	Micro-topography	6.7681	0.00****
2004	Aspect	0.0314	0.859
	Micro-topography	6.0567	0.00****

In 2003, the control and the swale (contour) habitats had the highest species richness compared to the other three micro-topographies, and the mound-down and disturbed habitats having the lowest species richness scores (Figure 7).

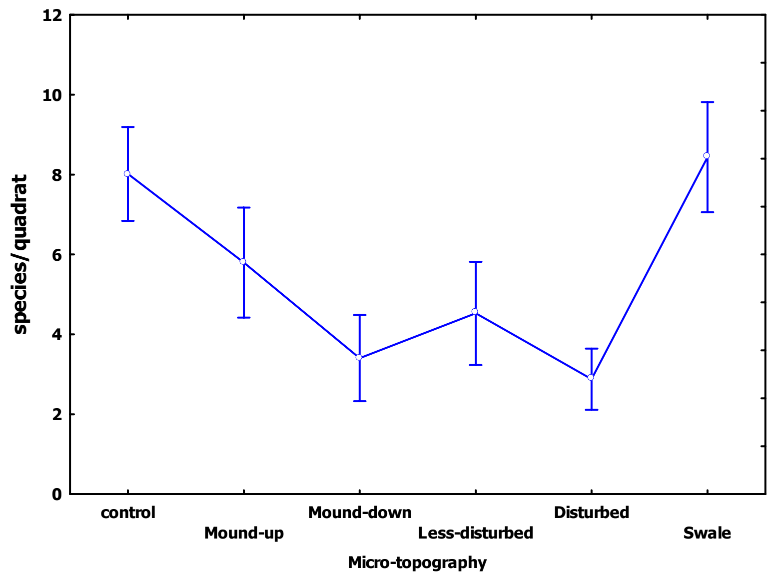


Figure 7: Species richness by micro-habitat in 2003.

Similar differences were found between micro-habitats in 2004, except for the disturbed micro-habitat that demonstrated similar species richness scores to the control and the swale habitats.

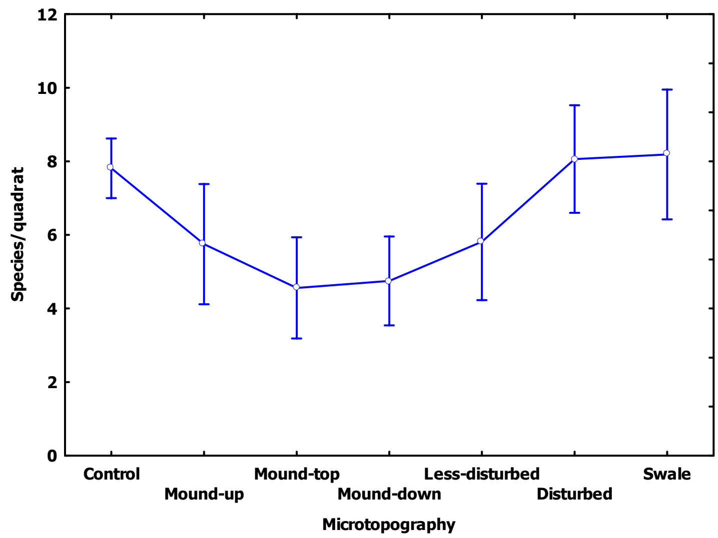
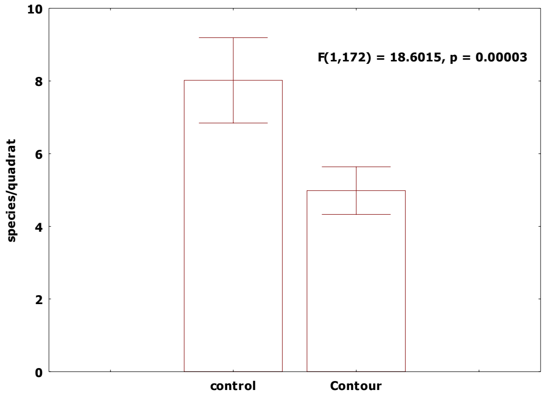
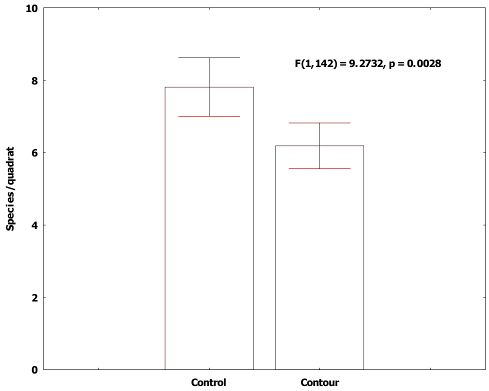


Figure 8: Species richness by micro-habitat in 2004.

Comparing 2003 and 2004 reveals a relative increase in species richness in the more disturbed micro-habitats (mound, disturbed and swale). Comparing all the contour micro-habitats as a single habitat showed significant lower scores in the contour compared to the control sites (Figure 9). However, compared to 2003, this difference was slightly diminished in 2004.



2003



2004

Figure 9: Species richness in contour vs. control sites in 2003 and 2004.

Evenness (species dominance equality)

Both the 2003 and 2004 surveys showed similar significant effects of micro-topography on species evenness. However, although the micro-topography had significant effect on species evenness in 2003, Tukey HSD comparisons showed no significant differences among individual habitats. The mound-down and the less disturbed habitats had lower evenness than others (Figure 10). The most apparent difference was between the most disturbed micro-habitats (mound-up, mound-top, mound down) and the other micro-habitats. Slope aspect significantly affected species eveness in 2004 but not in 2003 (Table 4).

Table 4: The effects of slope aspect and micro-habitat on species evenness in 2003 and 2004

	Factor	F	p
2003	Aspect	0.262	0.609
	Micro-topography	3.558	0.004**
2004	Aspect	4.690	0.032*
	Micro-topography	2.500	0.028*

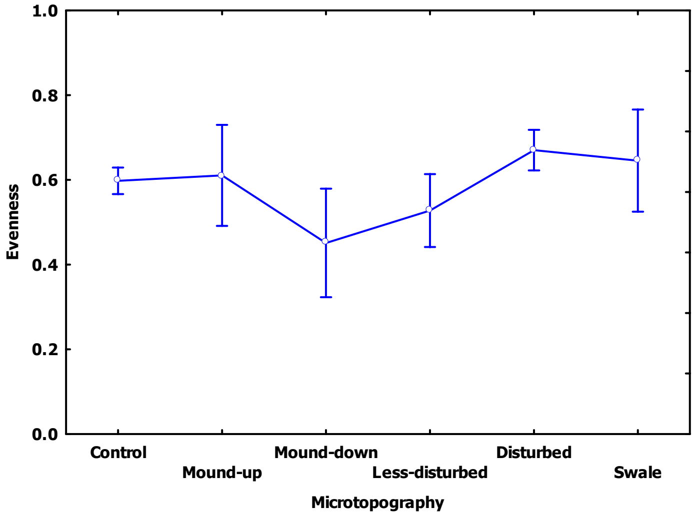


Figure 10: Species evenness by micro-habitat in 2003.

Evenness in west facing plots was significantly lower than in east facing slops (Figure 12).

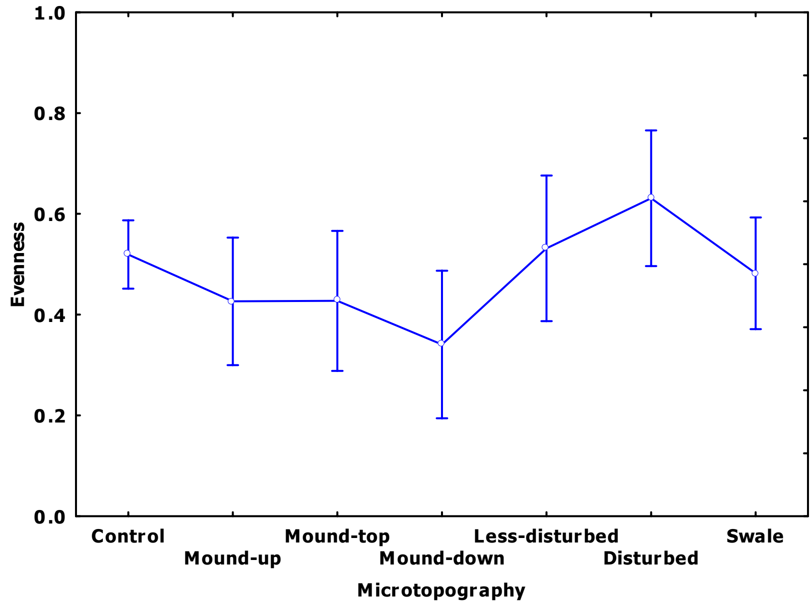


Figure 11. Species evenness by micro-habitat in 2004.

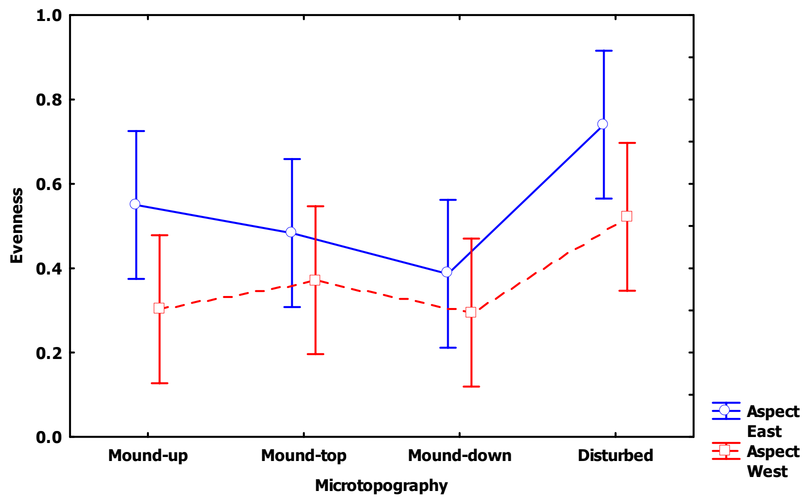


Figure 12: The effect of aspect on species evenness in 2004

Comparing the entire contour habitat as whole to the controls revealed no significant differences in species evenness in either year (Figure 13).

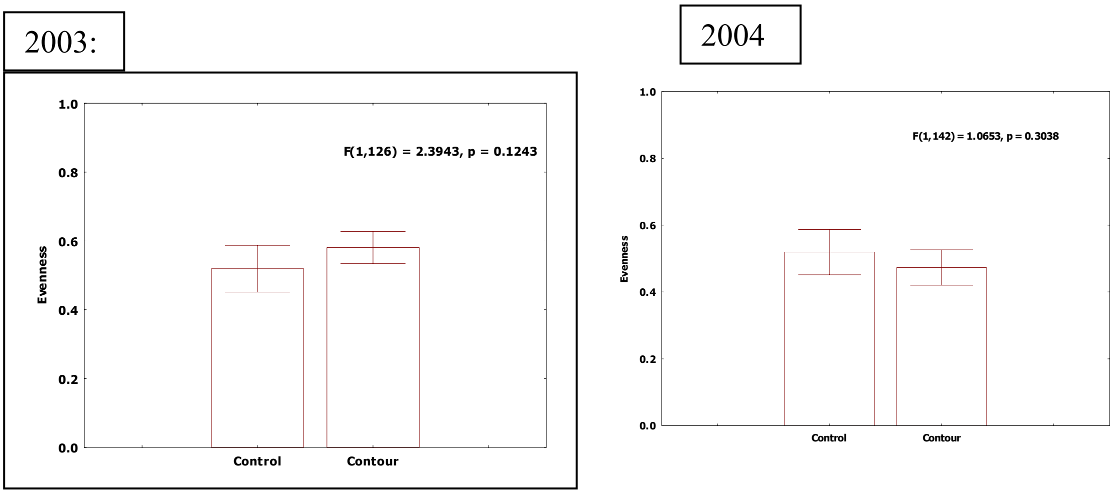
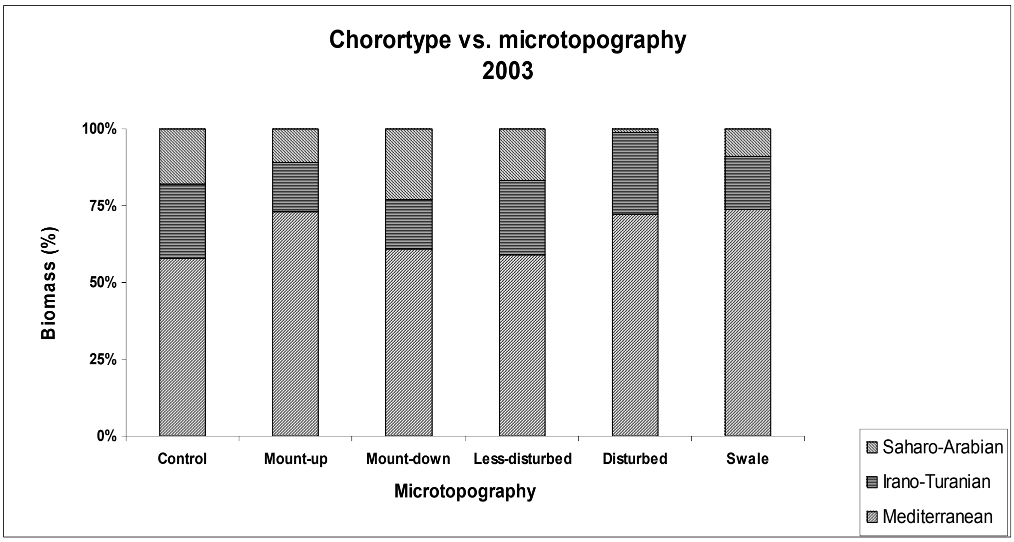


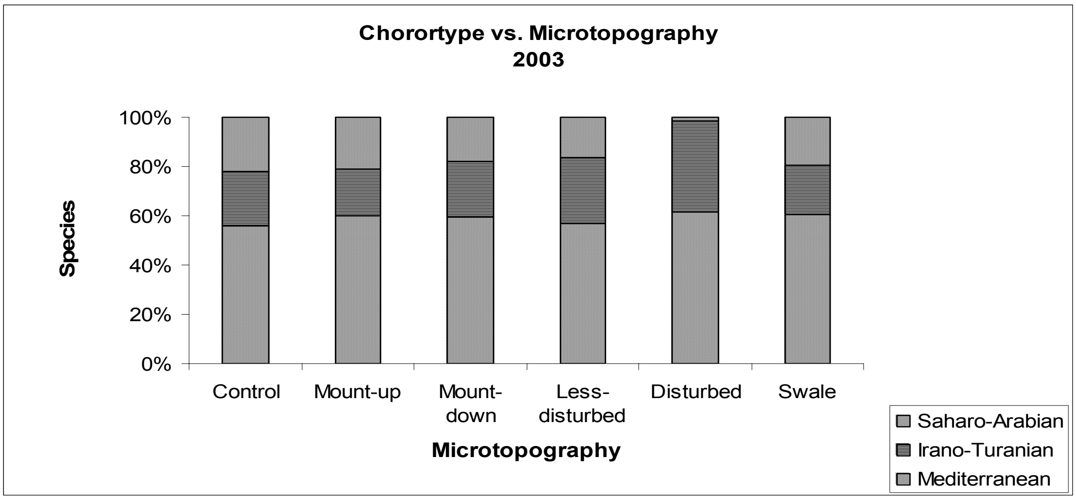
Figure 13: Species eveness in contour vs. control sites in 2003 and 2004.

Chorortype

Analyzing species compositions according to their global geographical distributions (chorotypes) revealed similar distributions across different habitats and micro-habitats (Figure 11).



a



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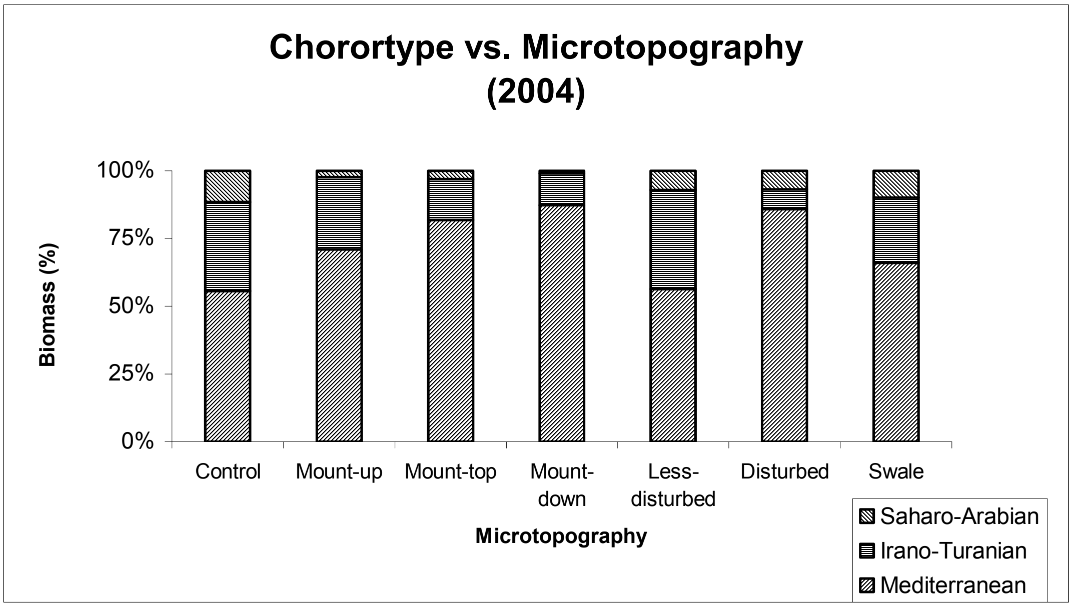

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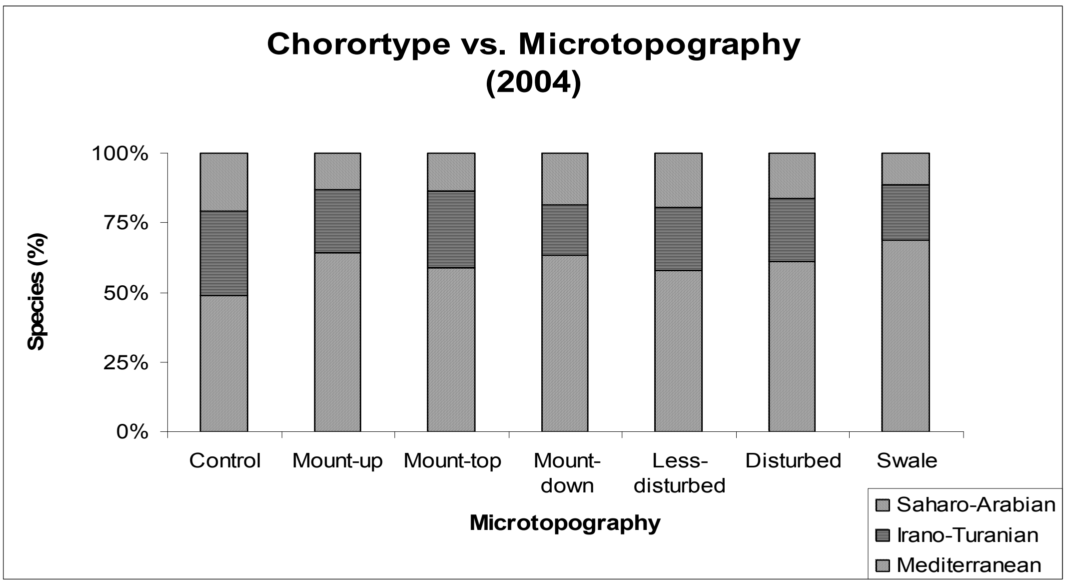

d

Figure 14: Distribution of species chorotypes (species numbers and % biomass) across different micro-habitats in 2003 and 2004.

Although the distribution of species numbers and biomasses did not reveal any significant differences between the studied micro-habitats, the data reflects the typical composition of a fringe semi-arid Mediterranean community, with the Mediterranean type as a dominant followed by the Irano-Turanian type and the Saharo-Arabian as a minor component.

Main trends and interim conclusions

Plant biomass production: Although there were differences in plant mass production among the contour micro-habitats, both the 2003 and 2004 data demonstrated no significant overall differences between the contour habitat as a whole and the untreated control habitat. This means that although only 4-5 years passed since the great disturbance (removal of <80% of all plants and biomass) that accompanied the initial construction of the contour topography, biomass production by natural vegetation recovered relatively swiftly and is already compensated for. Reviewing the current vegetation % cover gives a strong expectation in the long run, after fuller plant colonization and vegetation regeneration, the total mass production in the contour sites will greatly exceed that of the control sites.

Slope aspect: the consistent lack of slope aspect effects are slightly surprising given the low levels of precipitation in Yatir. It is suggested that the slope aspect effects are relatively subtle compared to the more prominent effects of micro-topography and other local random factors. Further inclusion of slope aspect as a main factor will be reconsidered- dropping it may allow more detailed sampling and analyses of other factors.

Species richness: as expected following a drastic disturbance, there is a significant decrease of species richness in contour trench compared to the control sites. However, species richness in swale and other contour disturbed habitats (in 2004) was showing slightly, although not significantly, higher scores than the control sites. As the processes of species colonization continues, we expect contour species richness to greatly increase over time and to possibly exceed that of the controlled sites.

Species evenness: no significant differences were found among the micro-habitats within the contour habitat or between the entire contour habitat and the untreated control. Further analysis is needed to reveal whether this finding is representative and relaible, a reflection of a temporary (successive) state, or a mere consequence of a low statistical power.

Species chorotypes: although the three main chorortypes were represented differently in the biomass of the different micro-habitats, their proportion was relatively similar and could not reflect any obvious differential trends. It is suggested that further species colonization and greater biomass production in the next few years might reveal clearer trends that are currently obscure due to the young colonization stage of the contour habitats.

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Vegetation monitoring by remote sensing

Research team

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20.06.04

Objectives

Leaf Area Index (LAI) is defined by one-sided green leaf area per unit ground area. Since LAI affects the amount of intercept light, it is an important structural parameter for quantifying the energy and mass exchange characteristics of terrestrial ecosystems such as photosynthesis, respiration, transpiration, carbon and nutrient cycle, and rainfall interception (Gong et al., 2003). The objectives of the work are: (1) estimating leaf area index (LAI) from remote sensing data; and (2) producing satellite-derived LAI map for the Yatir forest.

Methods

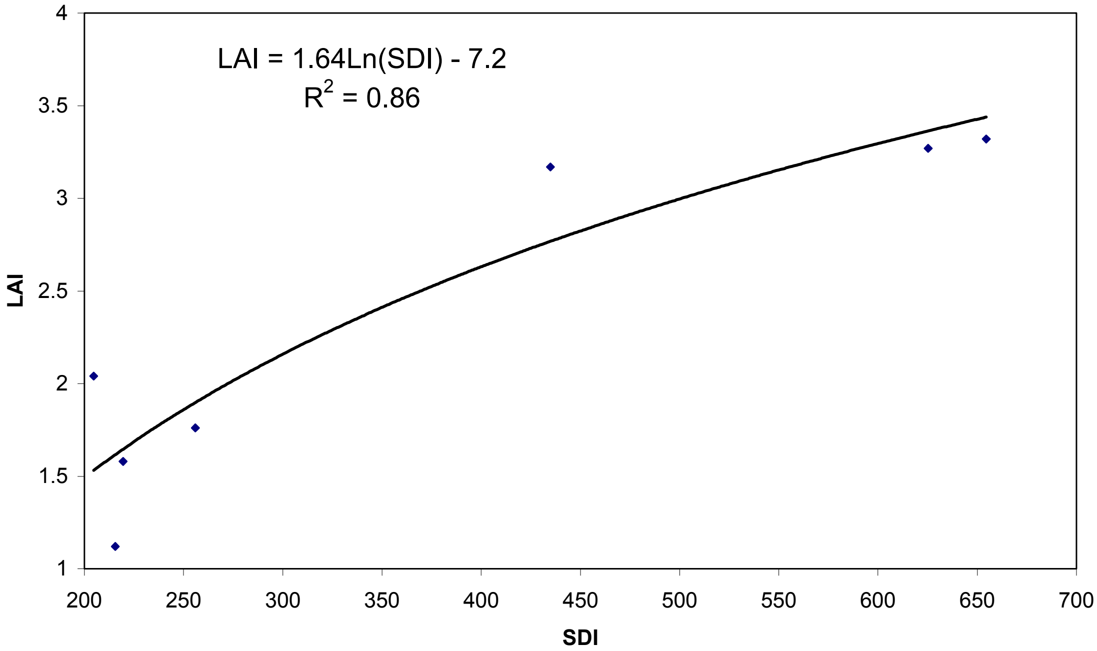
For implementing these objectives field and image processing methods were used. The fieldwork includes LAI assessment by indirect method, which is estimating the light interception within the canopy (Eklund et. al., 2001). The measurements were done using the ΔT- SanScan Canopy Analysis System that measures a photosyntheticly active radiation beneath the canopy for defining transmittance and calculating LAI using Normann and Campball approach (1989). 7 forest plots were selected with different stand density and were sampled in two campaigns, in March and May 2004, each throughout the whole day in order to relate the LAI to different solar zenith angles. The density was defined by JNF as a number of trees per unit area (hectare in our case) and expressed as Stand Density Index (SDI) following Reineke (1933).

Results

The relationships between LAI and the SDI are presented in Table 1 and Figure 1. It is possible to see that the denser the site the higher the LAI. The logarithmic regression coefficient is $R^2 = 0.86$.

Table 1 LAI estimation over seven sites with different stand density, which is represented here by Stand Density Index (SDI). It is possible to see that the denser the site the higher the LAI (the logarithmic regression coefficient is $R^2 = 0.86$).

Site	SDI	LAI
D1	625.25	3.27
BY	654.65	3.32
BYW	434.90	3.17
B3	215.57	1.12
Grid 1	256.00	1.76
Grid 2	219.46	1.58
Grid 3	204.70	2.04



<u>Figure 1:</u> Leaf Area Index (LAI) as a function of different stand density expressed as Stand Density Index (SDI).

A 2-meter resolution IKONOS image was obtained on 21 March, 2004. The image was radiometrically, atmospherically, and geometrically corrected according to UTM grid, datum WGS-84, and zone 36, North. The research sites were detected using Global Positioning System (GPS) and subseted from the image using ERDAS Imagine image processing software.

There are two possible approaches to calculate LAI from spectral reflectance spaceborne data. One is to use simple correlation between *in-situ* measurements and any spectral vegetation index, which will be appropriate to give a right description of vegetation at each site according to its density. The other, which is more complicated, is to follow three consequent steps to LAI calculation:

1. To calculate spectral vegetation index.
2. To calculate fractional vegetation cover from this index, which is actually the percent forest area occupied by the vertical projection of tree crowns
3. To calculate LAI from a fractional vegetation cover according to an exponential relationship between those two factors.

At this stage it was decided to follow the second approach, to examine eight different spectral vegetation indices and to compare them with the *in-situ* LAI measurements. Table 2 depicts the preliminary results of those calculations and comparisons for each chosen index.

<u>Table 2</u> A comparison between eighth spectral vegetation indices that were calculated over seven research sites, *in-situ* measured data and stand density index (SDI). Best correlations were found between the Modified Weighted Difference Vegetation Index (MWDVI) and the Normalized Difference Vegetation Index (NDVI) and the Leaf Area Index (LAI).

Index	BY	D1	B3	BYW	Grid1	Grid2	Grid3	R^2 (LAI)	R^2 (SDI)
SAVI	1.69	2.19	2.15	1.95	2.71	1.65	2.16	0.08	0.08
MSAVI	2.04	2.07	2.05	2.12	1.95	1.87	1.93	0.44	0.40
TSAVI	1.55	1.56	1.56	1.68	1.23	1.01	1.11	0.40	0.42
NDVI	2.73	2.85	2.61	3.15	2.61	2.52	2.78	0.63	0.21
MWDVI	2.00	2.09	1.89	2.36	1.78	1.83	2.05	0.64	0.21
WDVI	1.60	1.62	1.60	1.66	1.50	1.50	1.55	0.48	0.37
RDVI	2.07	2.10	2.07	2.17	1.99	1.92	1.99	0.51	0.39
EVI	1.67	3.00	2.80	1.91	2.19	1.50	3.89	0.01	0.05

The results show that the Normalized Difference Vegetation Index (NDVI) and Modified Weighted Difference Vegetation Index (MWDVI), highlighted by bold, are best correlated with measured data, which indicates some relationships between them and LAI , but a weak correlation between those indices and site density is still inquiring there further examination at additional locations within the forest.

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Watershed Management of the Central Part of Jordan Valley, Jordan

Under

Middle East Watershed Monitoring and Evaluation project

Project team:

Atef Al-Kharabsheh, Mohammed Shahbaz, Omar Rimawi, Radwan Al-Weshah, Salem Al-Oun, Rida Al-Adamat, Saad AlAyyash and Afaf Al-Adamat

Annual Report

2004

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Chapter one: Data Collection and Analysis

Introduction

Problems concerning water are considered the most important significant among those facing Jordan today's and even in the near future. They arise (mainly) from an arid to semiarid climate with low annual rainfall ranging from 600 mm in the northwest to less than 50 mm in the eastern and southern deserts which form the major part of the country, a high population growth as a result of refugees coming to Jordan and as a result of natural multiplication and the rapidly increasing demand for water for the agricultural and industrial needs.

Water shortages, soil erosion and sedimentation are serious problems in many parts in Jordan as an arid to semi-arid climate. Rainfall varies from years to year in quantity, distribution, intensity and duration. In such regions, soils are characterized by very low crop production resulting from periodic droughts and deteriorating soil properties. Cultivating such areas depends on solving problems associated with water resources and soil deterioration.

The main water source in Jordan is the rainfall, thus the need for rainfall water harvesting is needed to reduce soil erosion and sedimentation, which will reduce the loss of soil and increase soil water storage and soil fertility. More than 70% of available water is used in agriculture sector, therefore, good soil and water conservation management is needed to reduce the amount of irrigation water and to maintain good soil quality, by increasing the soil water harvesting structures. The concept of water harvesting is to collect (harvest) water from larger areas (catchments) and to concentrate it on a smaller (run on) area. Water harvesting has been used for many years in different areas of the world to combat the problem of irrigation water shortages.

Water harvesting means to understand the value of rain, and to make optimum use of the rainwater at the place where it fills. Soil and water conservation management is the application of engineering principles to the solution of soil and water management is the application of engineering principles to the solution of soil and water management problems. The conservation of these vital resources implies the maximum utilization of resource to obtain high level of production without affecting its future potential. This process is known as sustainable management of the resource.

Problems involved in soil and water conservation may be divided into erosion control; drainage; irrigation; flood control; moisture conservation; and water resource development. Moisture conservation entails application of modified tillage and crop management. Practices including natural and artificial mulching techniques, level terracing, contouring and other physical means of retaining precipitation on the land and reducing runoff and evaporation losses from the soil surface. Flood control consists of the prevention of overflow on low-land and reduction of low in streams during and after heavy storms while water resources development involves the collection and storage of surface water as well as the recharge and orderly development of ground water supplies.

In Jordan, due to the high demand on food to meet the increasing population growth, the incorporation of arid and semiarid areas in agriculture production has become a necessity. In these areas, surface runoff accelerates soil erosion and depletes the productivity of soils and produces sediment, which is one of the major pollutants of the environment. In addition, improper irrigation practices may result in further water quality deterioration. Therefore, conservation measures to reduce the rate of soil and water losses at tolerable rate are necessary in order to conserve soil fertility, improve crop production and to sustain productivity of these soils for future generation.

Theoretically, proper watershed management and soil practices will reduce the rainfall impact on soil and intensity of runoff and subsequently increase soil moisture storage from rainfall while maintaining low levels of soil erosion and sedimentation. The objectives of water harvesting will help in the followings:

a) Determine the effect of rainfall characteristics on soil moisture storage and runoff harvesting under different soil surface management
b) Determine the effect of rainfall characteristics on sediment height and soil erosion as affected by soil surface management.
c) Increase the artificial recharge of groundwater.
d) Increase the safe yield of aquifers.

Hydrometeorological Network

The hydrometeorological network in the studied catchment area comprises, climate stations, rainfall stations and runoff stations. It is composed from 3 meteorological stations measuring daily rainfall, temperature, humidity, radiation, wind speed and direction, 7 evaporation stations, 7 rainfall stations and 5 runoff gauging stations.

Climate

The climate in the Jordan Valley is predominantly of the Mediterranean type. A hot dry summer and cool hot winter characterize it, with two short transitional periods in between. The first starts around mid November and the second starts around end of April. The climate of the study area could be divided into two main types according to the topography: the hilly and Ghore areas.

The hilly area is characterized by its pleasant climate, it has cool dry summer and cold wet winter. The temperature in hilly regions could be described as cool temperature. In winter, this area experience cold weather and in January the temperature is rather low. The hilly area is represented by Dafali and Shananir climate station, whereas Mintar climate station represents the Ghore area.

There are three meteorological stations in the vicinity of the study area, one is located at Dafali representing the high lands, and the two are is at Mintar station representing the lower lands. The three stations measure: daily rainfall, temperature, humidity, radiation, evaporation, wind speed and wind direction (Appendix 2&3). The mean monthly temperature ranges from 11.6 ^{o}C in February to 29.1 ^{o}C in July at Wadi Dafali, while it ranges from 12.8 ^{o}C in January to 30.2.5 ^{o}C in July for Wadi Mintar (Tables 1,2 & 3).

Table 1. Monthly and Average of Climatoligical Parameters of Mintar 1 Station during The Year 2004

Climatic Parameters	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum Temperature C	15.74	18.81	24.11	27.96	30.93	33.25	36.54	34.64	34.05	31.08	23.2	16.5
Minimum Temperature C	8.48	9.12	13.62	15.81	17.38	20.01	22.54	21.51	20.91	19.82	14.18	8.14
Mean Temperature C	12.11	13.96	18.86	21.88	24.15	26.63	29.54	28.07	27.48	25.45	18.69	12.32
Wind Speed (Km/hr)	5.76	4.77	5.51	5.74	6.09	6.34	6.15	6.04	5.79	4.67	5.12	3.91
Sunshine Duration (hrs/day)	4	6.15	6.82	7.75	6.17	6.43	8.04	8.77	6.38	3.64	4.73	5.5
Relative Humidity (%)	82.12	76.24	75.48	73.58	70.97	66.13	61.09	61.48	58.72	58.75	64.63	71.24

Table 2. Monthly and Average of Climatoligical Parameters of Mintar 2 Station during The Year 2004

Climatic Parameters	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum Temperature C	16.43	19.6	24.93	28.91	31.91	34.18	37.48	35.59	34.96	31.8	24.03	17.32
Minimum Temperature C	9.27	9.93	14.03	16.23	17.74	20.28	22.96	22.29	21.65	20.38	15.03	9.11
Mean Temperature C	12.85	14.76	19.48	22.57	24.82	27.23	30.22	28.94	28.3	26.09	19.53	13.21
Wind Speed (Km/hr)	4.19	3.61	3.92	4.21	4.57	4.74	4.62	4.39	4.48	3.39	3.24	2.48
Sunshine Duration (hrs/day)	4.3	5.65	7.06	7.8	6.61	7.38	8.93	9.37	8.85	6.25	5.16	5.16
Relative Humidity (%)	82.96	77.67	75.16	73.41	69.98	66.01	60.86	62.77	60.21	60.3	64.86	71.6

Table 3. Monthly and Average of Climatoligical Parameters of Dafali Station during The Year 2004

Climatic Parameters	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sep.	Oct.	Nov.	Dec.
Average Wind Speed (Km/hr)	5.94	4.51	5.57	5.23	5.48	5.77	5.38	5.21	4.77	3.89	5.16	4.24
Average Relative Humidity (%)	70.38	64.13	46.03	37.83	38.19	39.46	37.67	47.51	43.43	42.83	51.9	56.29
Average Air Temperature C	11.67	12.26	17.39	20.18	23.04	26	29.18	27.73	26.78	25.17	18.62	11.76
Average Soil Temperature C	11.86	12.99	17.7	25.77	31.71	34.22	39.19	37.13	34.01	30.49	20.88	12
Total Solar Radiation (Mj/M)	8.84	11.98	17.92	21.79	25.3	28.4	28.63	25.87	22.18	16.02	10.41	9.08
Dominant Wind Direction	E	S	W	S	S	W	W	W	W	W	S	S

Table 4. Evaporation Rate (mm) at Humrat Al Sahin during the Year 2004

Location	Jan.	Feb.	March	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Dafali	53.53	67.03	150.47	251.24	316.66	321.77	376.78	308.69	269.96	222.24	131.1	65.74
Mintar	71.36	80.02	165.6	266.39	332.69	336.86	393.08	324.63	284.8	237.45	144.27	79.16

Rainfall

The rain falls mainly in the winter season with its heavy fall in November and January (Fig. 1). Rainfall generally begins in October and lasts in May, the remaining months of the year are dry. The Cyclonic type of rainfall is reported to reach the region occasionally during the period from December to March.

There are seven rainfall stations in the study area. All stations measure the daily rainfall, and two of them have also rainfall recorders, giving hourly rainfall events. Table 5 represents the average monthly and annual rainfall for the year 2004/2005. The annual rainfall ranges from 365.2 mm at Wadi Dafali to 295.4 mm at Wadi Mintar (Table 5). Table 6 shows the storm rainfall for all stations located in the study area. Generally, the rainfall decreases from east at Wadi Dafali to West at Wadi Mintar. This density is sufficient for evaluation of regional distribution and the determination of annual averages, according to the World Meteorological Organization Guide (Fig. 2).

Fig. 3. shows rainfall correlation between Dafali station at the upper part and Mintar station at the lower part of the study area.

Table 5. Monthly and Average Rainfall for the Station (Dafali, Shananir1, Bee, Shananirr2, Green House, Date Palm, Mintar) during the Year 2004/2005.

Rainfall Station	Month								Annual Total
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	
Dafali	0.6	109.8	32.2	121.8	56.8	30.6	6.6	6.8	365.2
Shananir 1	0.4	105.4	32	116	52.8	28.4	6.2	6.6	347.8
Bee	0.4	106.6	27.8	102.4	47.4	26.8	5	6.4	322.8
Shananir 2	0.4	103.6	28.8	97.2	44.6	25.8	5	6	311.4
Green House	0.4	104.6	27	98.2	43.2	25.2	4.8	5.4	308.8
Date Palm	0.4	103.2	26.6	94	41	24.8	4.6	5	299.6
Mintar	0.4	101.8	25.8	89.6	44.2	24.6	4.6	4.4	295.4

Table 6. Storm Rainfall analyses of Rainfall Stations arranged from Top to Bottom.

Date	Dafali	Shananir1	Bee	Shananir2	Green House	Data Palm	Mintar
28.10.2004	0.6	0.4	0.4	0.4	0.4	0.4	0.4
17.11.2004	34	33	33	32.8	32	31.4	30.8
18.11.2004	12.8	12.4	12.2	12	12	11.6	11.2
22.11.2004	45.8	43.8	44.8	43.2	43.6	43	42.4
23.11.2004	1.2	1	1	0.8	0.8	0.8	0.8
26.11.2004	14.2	13.8	14.2	13.6	14.8	15.2	15.6
27.11.2004	1.8	1.4	1.4	1.2	1.4	1.2	1
07.12.2004	4.4	6	4.2	5.8	3.8	3.6	3.2
08.12.2004	12.6	12.2	12	11.4	11.8	11.4	10.8
15.12.2004	1	0.8	0.2	0.4	0.2	0.8	0.8
16.12.2004	0.6	0.6	0.8	0.4	0.6	0.4	0.6
21.12.2004	0.2	0.2	0.2	0.2	0.2	0.2	0.2
24.12.2004	10.8	10.2	8.6	9	8.4	8.8	8.6
25.12.2004	2.6	2	1.8	1.6	2	1.4	1.6
02.01.2005	15.4	14.8	12.2	12	10.4	9.8	9.4
03.01.2005	9.8	9.2	10.2	9.6	8.8	8.6	8.2
04.01.2005	5.2	5	3.8	3.6	4.8	4.6	4.4
05.01.2005	18.6	18.2	16.4	16.2	16	15.4	14.8
06.01.2005	2.4	2.2	1.2	1.4	2	2	1.8
15.01.2005	3.8	3.4	2.6	2.2	3.4	3.6	3.4
16.01.2005	0.4	0.2	1	0.8	0.6	0.4	0.2
18.01.2005	4.4	4	4	3.6	4	3.8	3.6
19.01.2005	32.6	31.6	28.2	27	27.8	27.2	26.8
20.01.2005	4.6	4.4	3	2.6	4.2	4	3.8
22.01.2005	16.6	15.8	13.6	12.8	10.8	9.8	9
23.01.2005	3.4	3.2	2.4	2.2	2.4	2.2	2
24.01.2005	4.6	4	3.8	3.2	3	2.6	2.2
01.02.2005	1.8	1.6	1.8	1.4	1.6	1.8	2
02.02.2005	1.8	1.6	1.6	1.2	1	0.8	1
04.02.2005	4.2	3.8	3.2	3	3	3	3.4
05.02.2005	3	2.6	2.4	2	1.2	1	1.2
06.02.2005	12.4	11.6	10.2	10	10.4	10.8	11.4
07.02.2005	12.6	12	10.2	9.8	8.8	8	8.4
08.02.2005	13	12.4	11.6	11.2	11	10.2	10.8
11.02.2005	1.4	1.2	1	1	1	0.8	1
12.02.2005	6.6	6	5.4	5	5.2	4.6	5
04.03.2005	1.2	1	0.8	0.8	0.4	0.2	0.2
07.03.2005	1	0.8	0.8	0.6	0.6	0.6	0.6
08.03.2005	0.2	0.2	0.2	0.2	0.2	0.2	0.2

09.03.2005	20.4	19.6	18.6	18.2	17	17	16.6
10.03.2005	2.2	2	1.4	1.2	2.4	2.2	2.2
11.03.2005	0.8	0.6	0.6	0.6	0.2	0.2	0.2
12.03.2005	4.8	4.2	4.4	4.2	4.4	4.4	4.6
02.04.2005	4	3.8	2.4	2.6	3	2.8	2.8
03.04.2005	1.4	1.2	1.4	1.2	0.8	0.8	0.8
04.04.2005	1.2	1.2	1.2	1.2	1	1	1
04.05.2005	6.8	6.6	6.4	6	5.4	5	4.4
Total	**365.2**	**347.8**	**322.8**	**311.4**	**308.8**	**299.6**	**295.4**

Runoff

Runoff is a function of precipitation, soils, ground cover, elevation of catchment and slope; of these factors precipitation is the most variable. The shape of the drainage basin also governs the rate at which water enters the stream. In general, there are two types of catchments, fan shape and fern leaf catchments. The fan shaped catchments give greater runoff, because tributaries are nearly of the same size and therefore, time of flow is nearly the same and is smaller. Whereas in the fern leaf catchment as in most of the studied catchments, the tributaries are generally of different lengths and the time of concentration is more as the discharge has to travel longer distance. A number of major wadis drain into the Dead Sea without utilization. These wadis are characterized by narrow to wide shallow flow-beds with relatively high slopes.

During the rainy season high amounts of rainfall may occur over the heights resulting intermittent flood runoff in winter months and in the other days of the year some perennial flow from springs may be seen in the main wadis. These base flows are mainly the water being diverted for the use for irrigation in the study area.

To monitor runoff five gabions were constructed and equipped with automatic water level recorders two of them on Wadi Dafali, two on Wadi Shananir and one on Wadi Mintar during this year. The runoff volumes range from 18.3 m3 in Mintar catchment area to 1690.1m3 in Dafali catchment area which includes two runoff gauges (Table 7).

Table. 7.Volumes of runoff at gauging station

Dafali Gauging Station

Date	Discharge Q (m^3)	Length(m)	Hight(m)	Time(sec)	Volume(m^3)
17/11/2004	0.002	1.8	0.015	2700	4.46
	0.002	1.8	0.015	900	1.49
	0.133	1.8	0.28	1200	160.02
	0.106	1.8	0.24	1800	190.47
	0.007	1.8	0.04	1800	12.96
	0.194	1.8	0.36	900	174.96
	0.155	1.8	0.31	2700	419.42
	0.010	1.8	0.05	900	9.06
22/11/2004	0.211	1.8	0.38	1800	379.48
	0.148	1.8	0.3	900	133.10
	0.010	1.8	0.05	900	9.06
	0.005	1.8	0.03	1800	8.42
26/11/2004	0.010	1.8	0.05	2700	27.17
	0.005	1.8	0.03	900	4.21
	0.003	1.8	0.02	660	1.68
05/01/2005	0.028	1.8	0.1	1500	42.69
	0.010	1.8	0.05	900	9.06
	0.010	1.8	0.05	2700	27.17
				Total	**1614.86**

Mintar Gauging Station

Date	Discharge Q (m^3)	Length(m)	Hight(m)	Time(sec)	Volume(m^3)
17/11/2004	0.010	1.2	0.065	900	8.95
	0.002	1.2	0.025	300	0.71
	0.005	1.2	0.04	1800	8.64
				Total	**18.30**

Dafali2 Gauging Station

Date	Discharge Q(m^3)	Length(m)	Hight(m)	Time(sec)	Volume(m^3)
22/11/2004	0.002	1.2	0.02	1800	3.05
	0.002	1.2	0.02	900	1.53
26/11/2004	0.038	1.2	0.16	1200	46.08
	0.016	1.2	0.09	900	14.58
	0.011	1.2	0.07	900	10.00
				Total	**75.24**

Shananir 1 Gauging Station

Date	Discharge Q(m^3)	Length(m)	Hight(m)	Time(sec)	Volume(m^3)
17/11/2004	0.058	1.2	0.21	600	34.64
	0.022	1.2	0.11	600	13.13
	0.009	1.2	0.06	600	5.29
	0.005	1.2	0.04	900	4.32
22/11/2004	0.071	1.2	0.24	1200	84.65
	0.022	1.2	0.11	600	13.13
	0.028	1.2	0.13	300	8.44
26/11/2004	0.080	1.2	0.26	600	47.73
	0.046	1.2	0.18	300	13.75
	0.011	1.2	0.07	1200	13.33
	0.001	1.2	0.01	600	0.36
05/01/2005	0.003	1.2	0.03	600	1.87
	0.002	1.2	0.02	300	0.51
	0.001	1.2	0.01	300	0.18
				Total	**241.34**

Shananir 2 Gauging Station

Date	Discharge Q(m^3)	Length(m)	Hight(m)	Time(sec)	Volume(m^3)
17/11/2004	0.042	1.8	0.13	600	25.31
	0.017	1.8	0.07	300	5.00
	0.013	1.8	0.06	300	3.97
22/11/2004	0.063	1.8	0.17	600	37.85
	0.024	1.8	0.09	600	14.58
	0.020	1.8	0.08	600	12.22
26/11/2004	0.005	1.8	0.03	2700	12.63
	0.063	1.8	0.17	600	37.85
	0.013	1.8	0.06	300	3.97
	0.010	1.8	0.05	600	6.04
	0.005	1.8	0.03	1200	5.61
				Total	**165.02**

Evaporation

Part of the precipitation that is not obtainable, as surface runoff is known as losses. The losses in precipitation are due to various causes, some of them evaporation, transpiration, and interception. Evaporation from water bodies and soil masses together with the transpiration from vegetation is termed as evapotranspiration.

There are three general methods commonly in use for measuring evaporation, which are mainly indirect methods: measurement from evaporation pans, such as Class A Pan, water budgets and corrections with climatic data (Experimental Formulas).

Evaporation pan (Class A Pan), is used in this study. To measure the evaporation rate from a surface, the standard USA Weather Bureau Class A Evaporation Pan is the most widely used method in Jordan. The annual evaporation for the year 2004 ranges from 2535021 mm at Wadi Dafali Catchment Area in the upper part to 2716.31 mm at Mintar Catchment Area at the lower part (Fig. 4). The highest evaporation occurs in July, while the lowest occur in January (Table 4) (Appendix 2).

Sedimentation

The rate and quantity of water that infiltrates into the ground is a function of soil type, soil moisture, permeability, ground cover, drainage conditions and duration of rainfall. It is well known that when water reaches the surface of a soil, a part of it seeps into the soil. This movement of water through the soil surface is known as infiltration and plays a significant role in the runoff process. Hence, infiltration is the primary step in the natural ground recharge.

The sediment thickness at Wadi Dafali in 2004 year were 36.8cm in Dafali collection and 5.2 cm in Dafali spring. On the other hand mean of sedimentation volumes were 404.8 m^3 in Dafali collection and 52 m^3 in Dafali spring (Table 8, Appendix 2), while no sediments were observed on Wadi Mintar.

The results of sieve analyses show that soils range from sany soils at the upper part at Wadi Dafali to sandy loam and sandy clay at the middle and lower part at Mintar Catchment Area.

Table. 8. Sedimentation Rates in the Reservoirs of Dams during 2004/2005

No.	Dam	Area(m^2)	Mean of Sedimentation thickness(cm)	Mean of Sedimentation Volume(m^3)
1	**Dafali collection**	1100	36.8	404.8
2	**Dafali spring**	1000	5.2	52

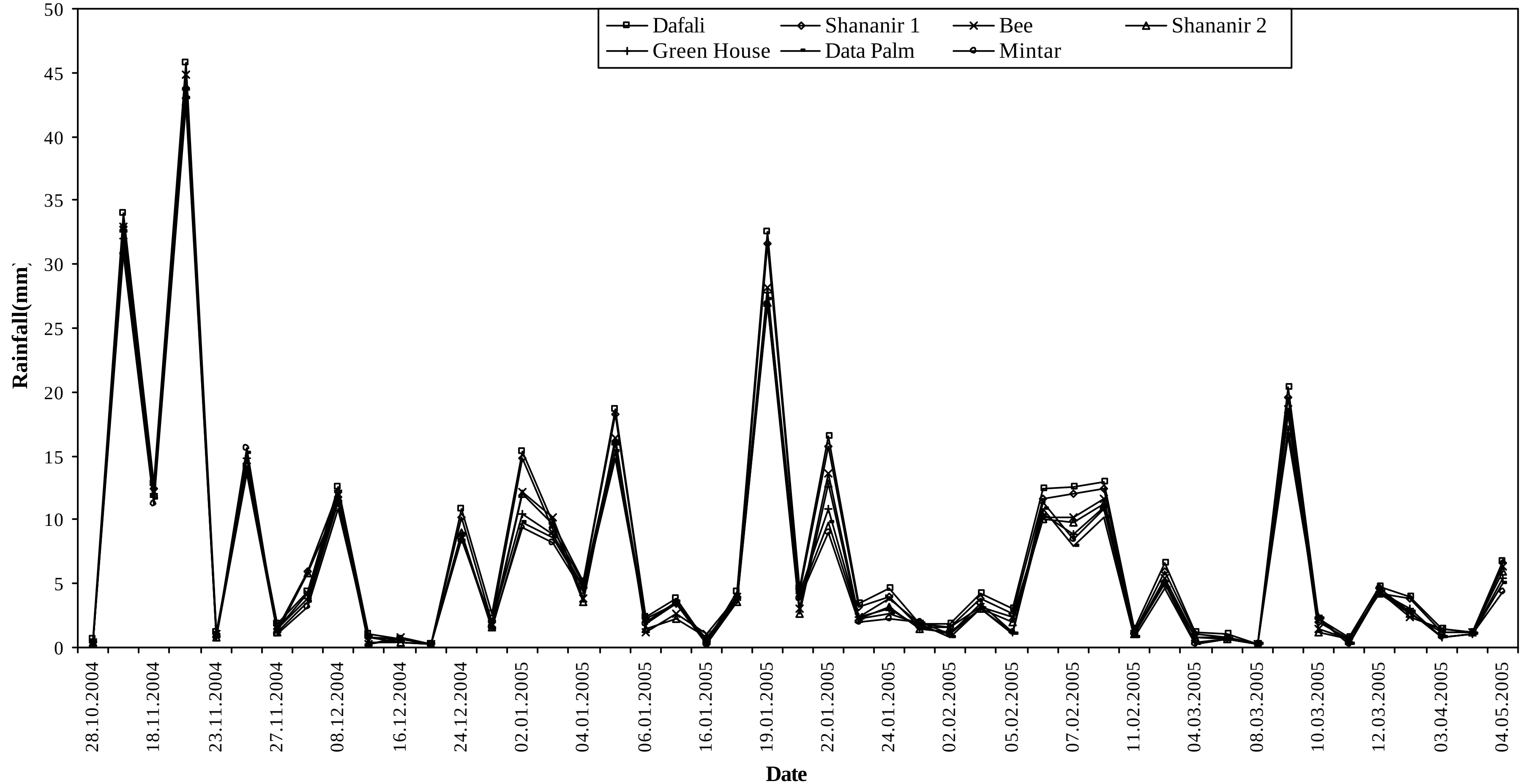

Fig. 1. Rainfall at Study area 2004/2005

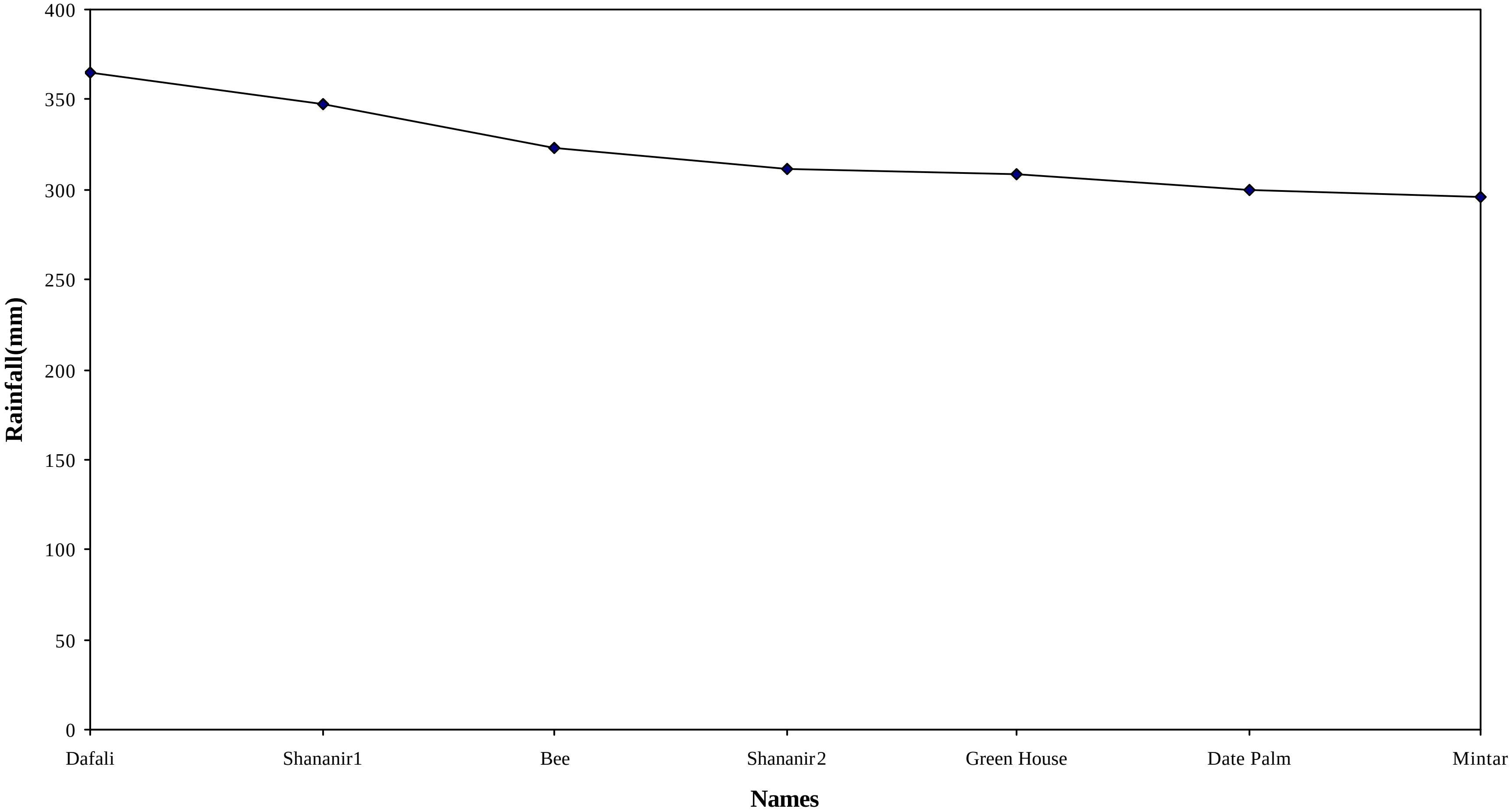

Fig. 2 .Trend of Rainfall Decrease from East to west.

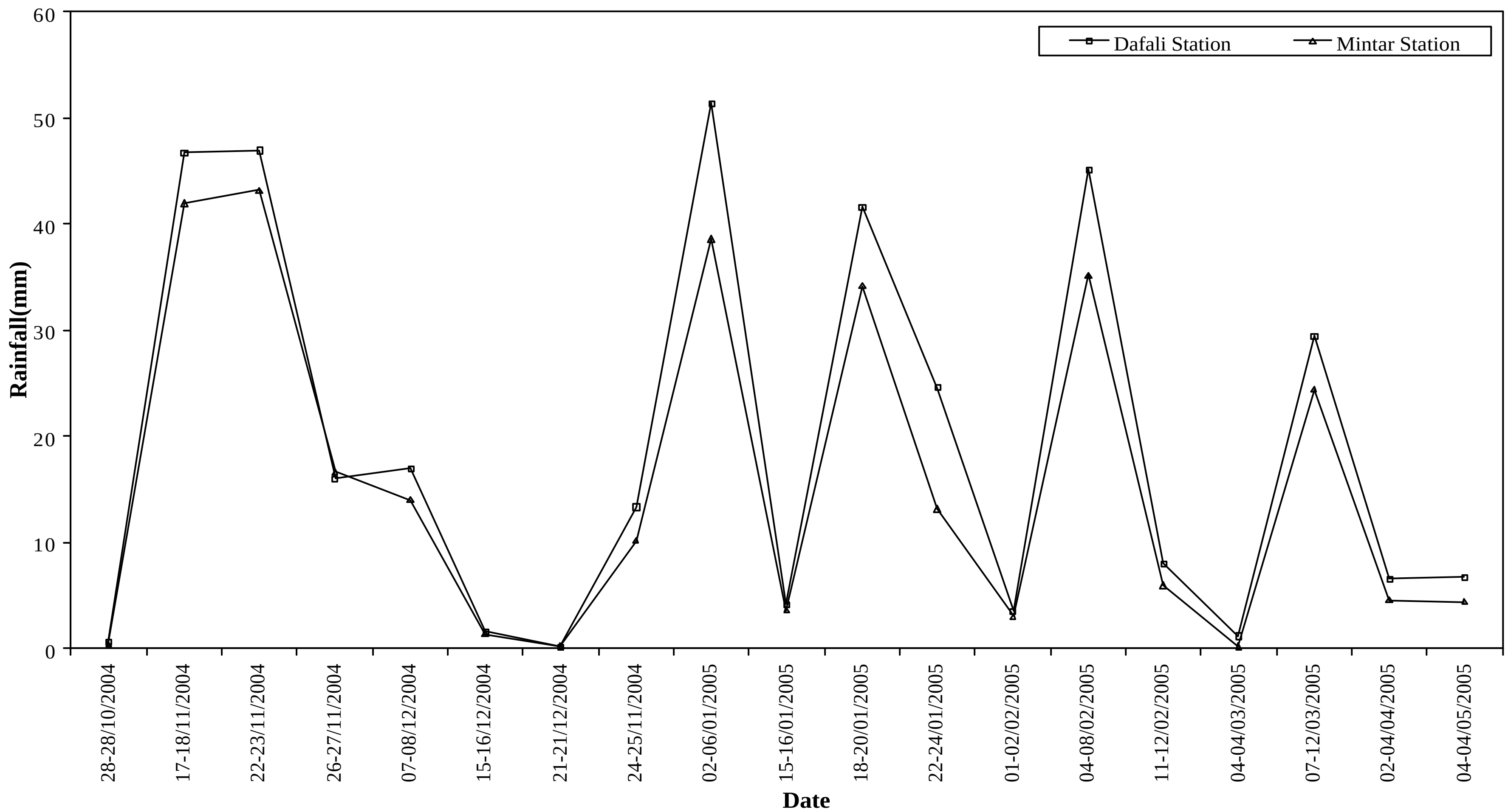

Fig. 3. Rain Storm at Study area 2004/2005

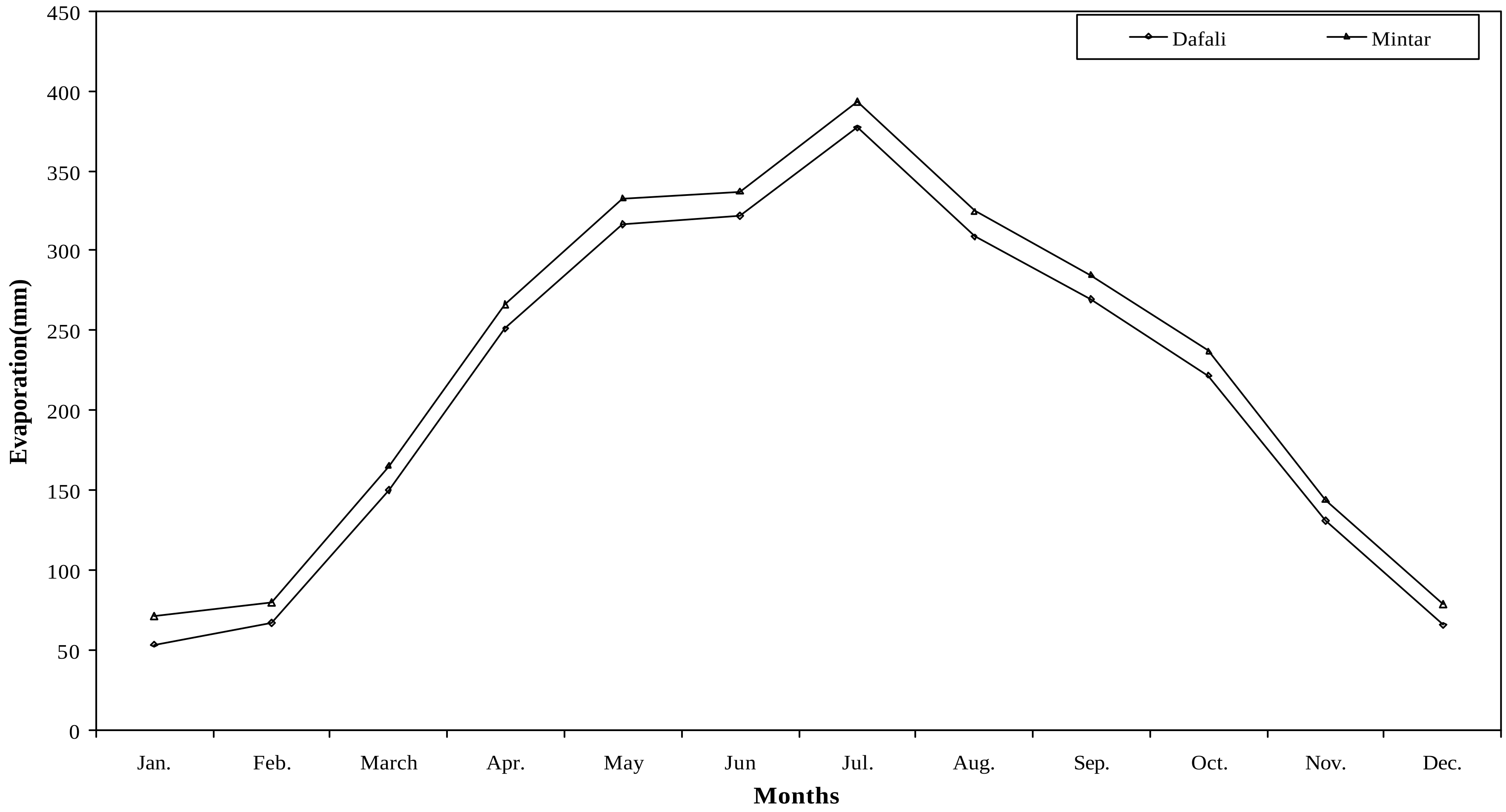

Fig .4 . Evaporation at Study area 2004

Chapter two: Mapping the vegetation cover in Humrit Al-sahin at Al- Salt.

Introduction

Vegetation cover which is defined as the vertical projection of plant material onto the ground when viewed from above, and expressed on an area basis, such as square meters/ hectare or square feet/ acre Bonham (1989), were studied from different aspects during 2003-2004 years in Humrit Al-sahin research station. A survey done through the past two years using different procedures: Line Intersect Method applied in 2003 spring growing season resulted in 106 plant species belonging to 91 genera and 23 family and the Randomly Quadrate Method that were applied in 2004 spring and summer growing season, also some biomass measurements were taken all over Humrit Al-sahin area and finally each plant species found were collected, preserved and mounted to a voucher specimen and kept in the herbarium which established and funded by the project.

Methodology

1. Vegetation survey:

A complementary survey was conducted using the Randomly Quadrate Method using the following procedure:

- The whole area was divided into two main blocks depending on:
    - ✓ The phytogeographical regions present there; the Sudanian regions (areas with elevation below zero) and Irano- Turanian regions (areas with elevation above zero).
- Then in each main block other blocks were taken based on:
    - ✓ Vegetation pattern.
    - ✓ Farming activities (Cultivated areas by the university)
    - ✓ North or south facing.
    - ✓ Road accessibility.
- Then within each block 3-7 samples were taken based on the size of the block (3 in the small blocks to 7 in the large ones).

- The samples were taken using 3x3 meters quadrates in the shrubs area (phryganic ecosystem) , and 1x1 meters quadrates in the (grassland ecosystem) area.
- Plant species were identified fully to the species level based on Flora Palaestina

2. Biomass measurements

The following steps were done:

- A number of representative quadrates samples were clipped in the field.
- Dry weights of the clipped quadrates were obtained by oven – drying samples at 105°C until they no longer lose weight.
- The representative samples dried consist of everything clipped in a quadrate without any separation of species or drying the individual plant alone.
- The weight of water in the sample is the difference between the fresh weight and dry weight.
- The summation of water obtained from all quadrates will divide on the whole sampled area of Humrit Al-sahin to assess the biomass (productivity) of the vegetation cover.

3. Herbarium

A herbarium was established in Humrit Al-sahin research station contains the voucher specimens of all plant species present in Humrit Al-sahin area and from many other places in Jordan, specimens were prepared according the following procedure:

- Plant specimens were collected.
- Identify fully to the species level
- Pressed to get rid of the moisture present in the plant by using a plant press.
- Stick it to a mounted sheet
- Label it (Figure 1).

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Flora of Jordan

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Family: ------------------------------------- **Herbarium No**.:------

Scientific Name: --

Common name:-------------------- **Locality:** -------------------------

Habitat:---------------------------- **Alt**.-------------------------

Leg.:-------------------------------- **Date**:-------------------------

Det. -------------------------------**:** **Funded by: Middle East Project**

Fig. 1. Label used for herbarium specimens.

Results

1. Vegetation Survey:

Flora of the surveyed area present in (Appendix 2, Figures (2 and 3)). In the spring and summer of the year 2004, we recorded 100 species belonging to 88 genera and 32 families (18 families not recorded in 2003). The best represented families were the *Compositae* (17 Genera and 17 species), *Gramineae* (14 Genera and 16 species) and *Labiatae* (7 Genera and 8 species. On the other hand, there are other families were represented only by one species (*Acanthaceae*, *Apocynaceae* ,*Capparaceae* and Rubiacea*e)*.

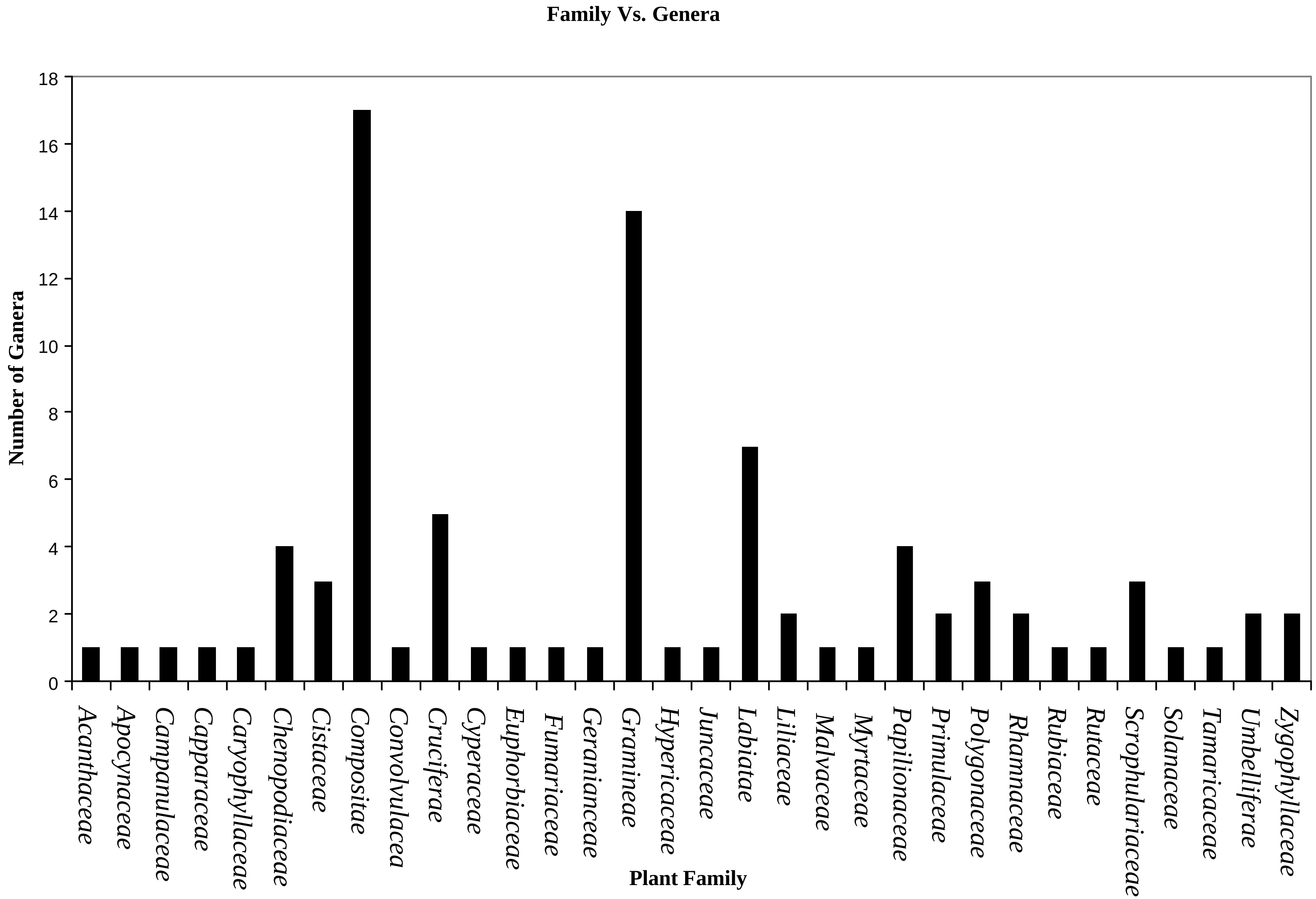

Fig. 2. Number of genera for each family at Humrit Al-sahin in spring &summer,2004

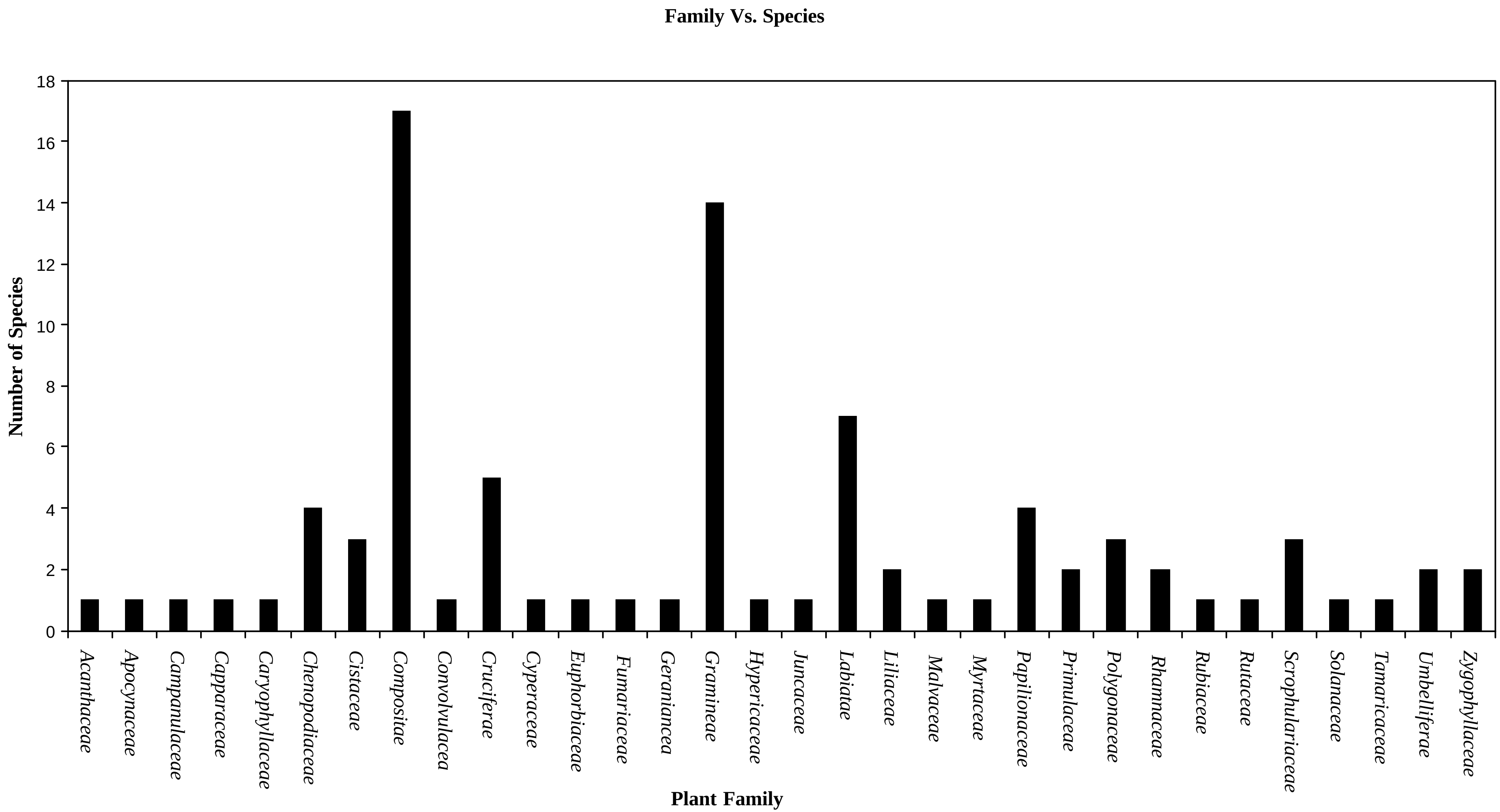

Fig. 3. Number of species for each family at Humrit Al-sahin in spring &summer, 2004

2. Biomass Measurements

Table1 shows the biomass values of Humrit Al- sahin vegetation cover in 2004 spring growing season, the biomass values range between (2.62- 49.89) g/m^2 with an average of 21.66 g/m^2 .

Table 1. Biomass Average rate values presented in g/m^2

Block no.	Biomass Average Rate g/m^2
1	11.35
2	7.85
3	3.96
4	6.29
5	8.99
6	4.50
7	7.57
8	5.46
9	2.62
10	11.59
11	27.49
12	18.40
13	47.44
14	49.89
15	24.41
16	43.45
17	23.65
18	33.33
19	14.46
20	27.38
21	21.27
22	41.89

3. Gallery:

Appendix 3 shows some of the plant species that present in the study area.

4. Herbarium:

List in Appendix 4 show that 373 plant species –collected from different places in Jordan basically Humrit Al-sahin - belonging to 221 genera and to 64 family were kept in the herbarium, work still in progress, many other species waiting preparation and identification.

Discussion

1. Vegetation Survey

Humrit Al-sahin represents an ecotone due to the intergradations of two phytogeographical regions (Figure 4). Ecotones are characterized by high plant and animal diversity. Survey of the vegetation and flora of the study area in the period (2003-2004) reveals the existence of 206 plant species classified in 153 genera and 41 families. The flora of this ecotone with a size of about 1000 hectares comprise around 8% of the plant species recorded from Jordan, 20% of the genera and 38% of plant families as well from this we understand the importance of studying and conserving such ecotones because of their high biodiversity. Mittermeier *et al*. (1998) stated that threatened areas of exceptionally high biodiversity like ecotones needs careful monitoring and conservation.

Ecotones allow the opportunity to plant species from other phytogeographical regions to grow in such as *Vaccaria pyramidata* Medik. and *Adonis* spp. that grows in Mideterranian region and *Pteranthus dicotomus* Forssk. that grows in Saharro arabian region.

In the survey of 2004, another 100 species were added to the total number of species reported in 2003. This could be attributed to the fact that the survey of 2004 was done in the spring and summer compared to the survey of 2003 which was carried out only in the spring Al-Adamat (2004), this difference will naturally give the chance for many species to grow. Many summer weeds like those belonging to the *Convolvulaceae* family such as *Convolvulus dorycnium* L., *C. arvensis* L and *C. althaeoides* L that were flowered from May to August, April to October and May to September respictivelly were collected Flora palestina (1978). These findings are in agreement with Smith and Ruyle (1991), who found that time of sampling is one factor that affect rangeland inventory or monitoring programs because of seasonal fluctuations

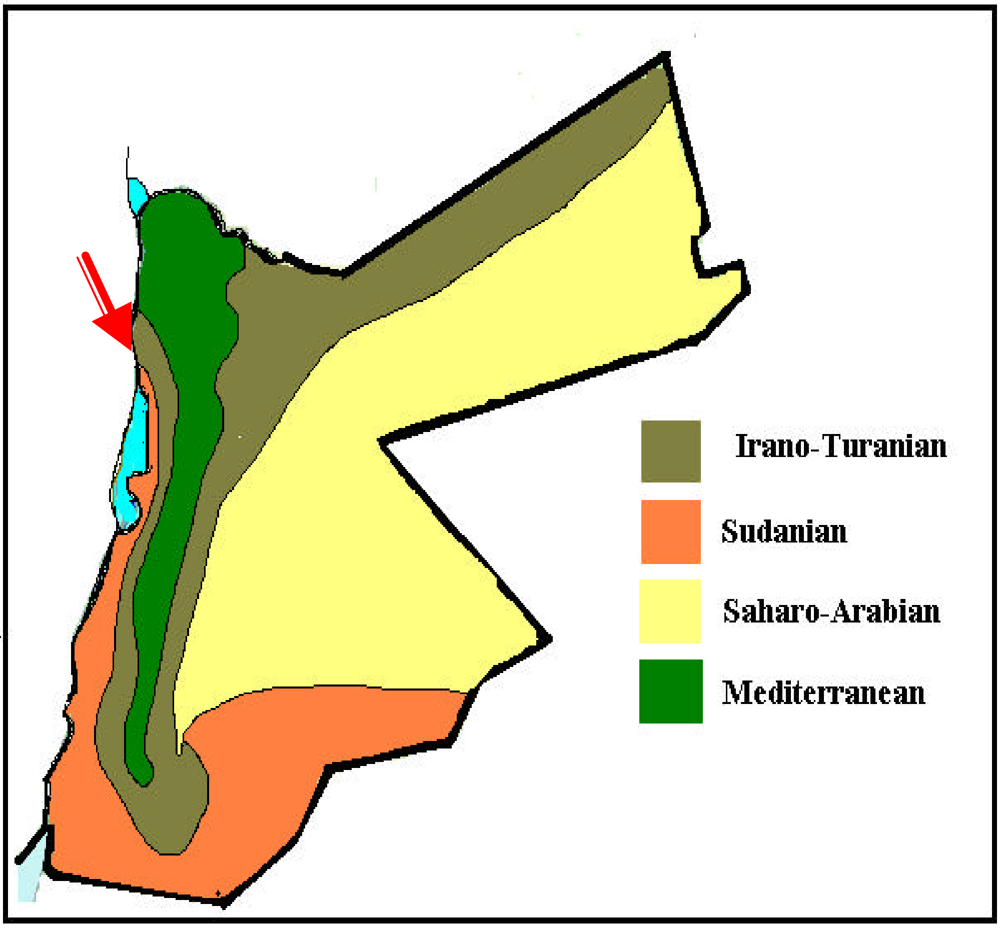

Fig. 4. Map showing the four phytogeographical regions in Jordan (Al-Gharaibeh, 2005).

The methodology used in 2004 spring and summer growing season (Randomly Quadrate Method) covered larger area and the blocks taken were more comprehensive, therefore the chance to find a species is better whereas the method applied in 2003 that is Line Intercept Method Al-Adamat (2004) was restricted to certain small areas, also the plant species intercepted to the line only put into our consideration.

According to Egli (1991) and Menjli (1994) Humrit Al-sahin contain two types of ecosystems phryganic and grassland ecosystems Al-Adamat (2004), this variation might cause this number of plant species survive there.

Compositae was the most dominant plant family (17 Genera and 17 species) in 2004 spring and summer growing season, that might be because of the environmental condition prevail there are highly adapted from the member of this family, this was in agreement with Luis et al. (2000) who stated that the different performance of plant species may become as a result of environmental condition prevail upon plant species.

Compositae dominance in the area could be attributed to their characteristic plumed fruits explains the high percentage of pogonochore type of diaspore. Most of *Compositae* family members produce a large number of mesophyte plumed minute achenes. This explains the dominance of this family in most studies carried in Jordan especially in arid areas (Boulos and Lahham, 1977; Boulos, 1977; Boulos and Al-Eisawi, 1977).

Gramineae (14 Genera and 16 species) was the second most dominant plant family after the *Composite*, that could be due to the fact that grasses have a phenotypic plasticity respond highly to severe conditions.

The increase in the protection period provides more insurance for plant species to grow Hatough et al (1986) stated that the protection of eastern Jordan reserve led to increase in the number of species and caused microclimate modification.

2. Biomass Measurements

Biomass is one of the most commonly measured attributes in range inventory or monitoring programs. Biomass data may be collected on an individual species basis, as species groups, or as a total weight for the vegetation. Units to express biomass should be selected so that actual plant weight is easy to visualize, such as lb/acre, kg/ha or g/m^2 according to vegetation abundance and objectives of the inventory or monitoring program Bonham (1989). Species composition may also be calculated as the contribution (percent by weight) that each species makes to the total biomass.

Biomass values were ranging from (2.62- 49.89) g/m^2 with an average of 21.66 g/m^2, these values may reflect many indicators concern the management of the rangeland.
The lowest values were present in the blocks studied in the Sudanian region (areas below zero level) where in fact poor vegetation cover found and if it is present plant species become stunted, this could be due to the different environmental stresses present there such as the high temperature and low rainfall prevail that affected the period of plant growth and cause a shortening in the life cycle.

The high values present in the phryganic ecosystems which is dominated by the shrubs and other plant differ in the size from the annuals spread in other blocks.

3. Herbarium

The herbarium, which becomes the repository of the specimens and notes permanently preserved, is a growing source of information about the vegetation of the area, and may represent the flora of a continent or more Porter (1966).

This achievement was not asked to be done as a task from the project tasks, but it was necessary to do it because it becomes an evidence of the presence of plant species recorded, and also used as a reference. Therefore all plant species collected from different places in Jordan basically Humrit Al-sahin were preserved in the herbarium.

373 plant species belonging to 221 genera and to 64 families were kept in the herbarium, until the moment of writing this report. Work still in progress and many other specimens will be kept in the herbarium and will be processed in the coming few months.

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Chapter Three: Graduate Studies

University of Jordan
Faculty of Agriculture

SURFACE WATER MODELING FOR HUMRET ES-SAHIN AREA

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Co supervisor:
Prof. Atef Al-Kharabsheh

By:
Maha Barakat Al-Hoot

2005

Introduction

Humret Es-Sahin watershed area extends from the western part of AL-Salt near Kufur Huda to King Abdullah Canal (KAC) in the Jordan Valley. It is un populated area and includes many hills. Many dendrites wadis are also present in the area such as Wadi Shananir, Wadi Um-Butmah and Wadi Dafali. The slope of these wadis is directed from northeast to southwest (NE-SW) to reach King Abdullah Canal (KAC).

The area shows an oval shape with its longest axis in the east to north (E-N) direction. The elevation increases from 200 m below the mean sea level near KAC up to 142 m above the mean sea level at Rujm El-Mintar and to 437 m at the upper northern part of the area near the main road. The slope reaches about 8 percent in most of the areas, but it exceeds this value in many areas such as EL-Hawieh and wadi Shananir where it reaches about 20%. Many springs are located in the area such as: Ain Shananir and Ain UM Taineh. All these springs are contact-fault springs discharging their water from the sandstone.

These special watershed characteristics, mainly the steep slop; cause the runoff from rainfall water to be very fast (reach the out let of the watershed in short period of time), which will led to erosion of soil in this area, removing of nutrient from the soil surface with runoff water, and a reduction in soil storage capacity since the infiltration rate is low. All of these will effect on the availability of water and nutreient for plants in this area. Also the springs disharge in this area will be reduced causing further problem, and the ground water recharge will affected too according to the previos reasons.

First thinking of a solution for these problems require studying the amount of runoff expected in the study area based on the available watershed characteristics data and meteorological data. Then based on the results, a suggestion solution to be raised.

So, the watershed modeling systems (WMS) will be used for studying Humret Es-Sahin area, which is a comprehensive modeling carrying the hydrological and environmental watershed analysis, developed by the environmental modeling research laboratories of Brigham Young University in corporation with U.S Army corps of engineer's waterways experiment station.

The selection of this model based on: (1) the objectives of this study.(2) the watershed characteristics for the study area since the model give the benefit of using interchangeable watershed parameters to get the same results.(3) the limitation of the availability of data since the hydrological data for this area is not for longer time.(4) limited project budget for data collection and analysis.(5) also this model can be used for small sub basins and large complex watershed.(6) the simulation of watershed runoff and stream flows in this model can be obtained easily from historical or design rainfall.(7) And the simplesty and high speed in obtaining the results.

Also WMS provides: (1) complete graphical interface of HEC-1 (Hydrologic Engineering Center, Flood Hydrograph Package-1), HEC-HMS (Hydrologic Engineering Center, Replace HEC-1), TR-20 (SCS Technical Release 20), TR-55 (SCS Technical Release 55), rational method, and other hydrologic routing models. (2) Automatically generate a HEC-1, HEC-HMS, TR-20, TR-55 or rational method model. (3) Compute the resulting runoff hydrograph. (5) Display the runoff modeling result in a variety of graphical plots, such as this comparison plot showing predevelopment and post development characteristics of the proposed sub division.

Using digital terrain data as geographic information system data (GIS) it can automatically delineate a watershed and sub basins of the delineation process, basic data such as area, slope, mean elevation, maximum flow distance and many other commonly used hydrologic parameters as curve number (CN), rainfall depth, roughness coefficient, etc.

The distinguishing difference between WMS and other application designed for sitting up hydrologic models like HEC-1 & TR-20 is its unique ability to take advantage of digital terrain data for hydrologic model development.

Litreature Reviews

In the past century, different studies were done using manual model techniques or computer modeling techniques. Some of these have been published in the literature.

Shanholtz, and et.al, (1972) used FORTRAN version of Stanford watershed model, without snowmelt, to generate stream flow data on 2-small agricultural watersheds. Five years of recorded data were used to calibrate the model after which 5 additional years were generated using the model parameters developed for the first period. The four most important parameters were: (1) interflow index (CC), (2) infiltration index (CBI), (3) lower zone storage index (FLZSN) and (4) an infiltration–evaporation index (EF) for applying a seasonal variation to infiltration. They found that the annual water yield estimates appeared to be within measurement accuracy while estimates of shorter periods tends to be less accurate and the maximum mean daily peak discharges were somewhat erratic.

Houck (1982) used mathematical programming models for real time reservoir operation. Five-different types of the objective functions used in the model some require trail and error and some not. He found that two types were clearly superior to the others and not require trail and error fitting. Those can operate a reservoir system either when correct benefit and loss function defining the effect of operation are available or when only descriptions (in the form of cumulative distribution functions) of desirable physical operations are available.

Yomtovian (1982) illustrated that simplified computational techniques of hydraulic analysis used to delineate flood plains with acceptable degree accuracy. The results indicated that when both the simplified manual and complex computer hydraulic computational techniques are applied to 3-creeks Apple, Burnt and Hay-in North Dakota the flood plain boundaries computed by both methods are preferred for determining the 10 to100 years flood evaluation. The mathematical model such as HEC-2 or the national weather service Dam Breat model, are recommended for the detailed studies which require an accurate knowledge of the flood elevations.

Shatanawi, and et.al. (1999) Showed that quantification of the water budget for Zarqa River basin on average of 73.73% from annual rainfall evapotranspired, 21.2% infiltrated and 3.86% appeared as direct run off. An applied hydrological models were performed to model the rainfall-runoff relationship for Zarqa River basin 3-lumped integral models based upon the concept of the unit hydrograph were applied to analyze the rainfall–runoff relationship on daily basis. These models are simple linear model (SLM), the linear variable gain factor models (LVGFM) and the non-linear models (NLM). The results demonstrated that the linear assumption is valid only for the first 2- antecedent days.

The simulation result shows acceptable applications for the LVGEM in terms of simulating runoff events in time of its occurrence and volumetric fitness.

Objectives

The main objectives of this study are:

(1) To study the watershed characteristics such as watershed size, slope(s), shape(s), land cover and land use, etc.

(2) To determine sub basin hydrograph and channel routing using different methods. And to calibrate the used methods using the historical rainfall, stream flow, and existing watershed conditions.

(3) To evaluate the usefulness of the model and to comment on needed changes or modifications.

All of the required data will be obtained from the records of Prince Tasnim Bento Ghazi Metrological Station for Technical Researches in Al-Balqa` Applied University.

Equipment

- Watershed modeling systems (WMS) requires PC Pentium with 8 MB RAM and R12 or higher.
- Rainfall stations data
- Runoff stations data
- Class A Pan for evapotranspiration data

Mathmatical Review

Water budget:

This method consists of drawing up a balance sheet of all the water entering and leaving a particular catchemnt or drainage basin. Then the water budget could be calculated by the following formula (4):

$$P + R_{in} - R_{out} + R_g - E_s - T_s = ?\, S_s \qquad (1a)$$

Where P is the total precipitation; R_{in} is the surface water inflow; R_{out} is the surface outflow; R_g is the ground water inflow to the surface; Es is the evaporation from the surface; Ts is the transpiration from the surface; and $?\, S_s$ is the change in surface storage.

In order to quantify the water budget for Humret Es-Sahin area, the above equation will be simplified according to the following assumptions:

1. The flow components R_{in}, R_{out} and R_g will be combined in R as direct runoff only.
2. The evaporation component E_s and transpiration component T_s are combined as evapotranspiration ET.
3. The storage component $?S_s$ does not change during the year, implying that $?S_s = 0$ because of high runoff due to step slope.

The surface hydrological budget of equation (1a) is then reduced to the following form:

$$P = R + ET + I \qquad (1b)$$

Where P is the rainfall; R is the direct runoff; ET is the evapotranspiration and I is the infiltration. All terms are in million cubic meter (MCM).

To determine the water budget for Humret Es-Sahin area in accordance with equation (1b), the monthly rainfall for each station and runoff volumes will be calculated for each year in the records. The approximation of actual evapotranspiration will be estimated by dividing the areas into polygons using Theissen polygon method. The potential evapotranspiration from each polygon will be assigned to the nearest station.

The infiltration will be determined by subtracting the monthly runoff and monthly evapotranspiration. If the infiltration is negative, then the evapotranspiration will be adjusted so that the negative infiltration values are eliminated.

Peak flow, Hydrograph and Routing estimation

Rational method is generally considered to be approximate model for computing the flood peak resulting from a given rainfall, with the runoff coefficient accounting for all differences between the rainfall intensity and the flood peak. Such differences result from infiltration, temporary storage and other losses.

The rational method is given as (5):

$$Q = k\,CiA \qquad (3)$$

Where Q is the peak flow in cubic meter per second, k is conversion factor = 1.008, C is dimensionless runoff coefficient, i is the rainfall intensity in mm/hr, and A is the catchemnt area in hectares.

Due to the assumptions regarding homogeneity of rainfall and equilibrium conditions at the time of peak flow, the rational method should not be used on areas larger than about 1mile^2 without subdividing the overall catchemnt into sub catchemnts including the effect of routing through any drainage channels.

The WMS includes an interface to the rational method, which can be used for computing peak flows on small urban and rural watersheds. The interface includes the capability to combine runoff from multiple basins. Two different methods will be used to determine the peak flow /Hydrograph at down stream confluence. They are: The rational method and time of concentration method.

The equation used to compute the time of concentration from basin geometric parameters is the kinetic wave equation (4):

$$T_c = k\, L^{0.6}\, n^{0.6} / i^{0.4}\, S^{0.3} \qquad (4)$$

Where T_c is the time of concentration (hr), L is over land flow length (ft), n is Manning`s roughness coefficient, i is the rainfall intensity (in/hr), and S is the average slope of the over land area (ft/ft), K = 0.93.

Traditionally the time of concentration is determined at down stream confluence by determining the longest combination of time of concentration and routing travel time. Give a time of concentration for the outlet, rainfall intensity can be determined from a rainfall-intensity-duration curve and peak flow can be computed.

The hydrograph for the confluence will be determined in the same manner they are determined for sub-basins, by using the peak flow, time of concentration and a dimensionless Hydrograph.

Alternatively, hydrographs for the sub-basins can be computed and the routed (lagged) and combined by summing of the confluence points. When using this method detention basin may be defined at confluence points in order to determine the effect of storage on the computations.

All the computations for peak flows, hydrographs, and routing will be carried out within WMS.

Methodology

Five rain gauges will be selected as fixed network from the records of Prince Tasnim Bento Ghazi Metrological Station for Technical Researches in Al-Balqa` Applied University. The area of influence for each rain gauge to be determined involving Thiessen method. The selected rain gauge will have complete records or can be completed for five hydrological years containing all essential information and historical records that occurred during the period of 1999 to 2004. The interpolated rainfall depth at any station will be determined as weighted average of the reciprocals of the sums of the squares at distances of the other nearly stations as in the next equation:

$$P_D= (p_A/r^2_A + P_B/r^2_B+ P_C/r^2_C)/(1/r^2_A + 1/r^2_B +1/r^2_C) \qquad (5)$$

Where:

P_D: the precipitation at the required station.

p_A , P_B, P_C : the precipitation at the near stations (station A, B, and C).

r_A , r_B , r_C : distances of the other nearly stations (A, B, C).

The methodology of this study based on the chosen model. Once the model is selected, the steps involved in watershed simulation analysis follow the next sequence:

- Obtain all necessary input data-rainfall, infiltration, land use and land cover, channel characteristics, stream flow, design floods, soil type, percent impervious, size, shape , and slopes of watershed.
- Evaluate and refine study objectives in terms of simulation to be performed under various watershed conditions.
- Choose methods for determining sub basin hydrograph and channel routing.
- Calibrate methods using historical rainfall, stream flow, and existing watershed conditions. Verify model using other events under different conditions while maintaining same calibration parameters.
- Perform model simulation using historical or design rainfall, various conditions of land use, and various control schemes for channels or diversions.
- Perform sensitivity analysis on input rainfall, routing parameters, and hydrograph parameters as required.
- Evaluate usefulness of the model and comment on needed changes or modifications.
- Generalized the model on similar watersheds

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Land suitability for water harvesting and soil water conservation at Humrat Al-Sahin area.

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Introduction

Jordan is suffering from shortage of water and this shortage arises from many factors such as low rainfall with uneven distribution, high losses due to evaporation and runoff, increased demand on water due to population growth, and climatic change in the area. The annual rainfall ranges from 600 mm in the northwest highlands to about 50 mm in the eastern Badia which covers about 91% of the area. The average annual precipitation volume is about 8500 MCM (million cubic meter) 92% of which lost by evaporation, and the rest goes for groundwater recharge and surface flows in valleys. Therefore Jordan water resources are completely dependent on rainfall. This means that utilization of surface water is very important for the different purpose. Different techniques such as water harvesting should be used to overcome the shortage of water and increases the efficiency of water use.

The term water harvesting is used to describe the process of collecting and storing rain water for later beneficial use from an area that has been modified or treated to increase precipitation runoff. The collected water can be used for most purposes but it usually thought of in terms of drinking water for livestock and domestic uses or for growing the plant (Frasier, 1988).

Soil erosion is the most significant ecological restriction to sustainable agricultural production on steeplands. Unsustainable practices on steep slopes pose a series of problems, such as flood and siltation, for downstream portions of the watershed. (Pimentel *et al*, 1995)

The study area (Humrat El-Sahen) has high slope area about of 8 percent in most of the areas and the runoff coefficient is about 0.25 (Al-Khrabsheh, 2000). That means

25% of rainfall are lost as runoff. Many trees were planted at steeping area and irrigated by drip irrigation system. If the runoff water collected and stored in the vicinity of the trees root zone it will help reducing the water shortage problem.

The utilization of water resources in this area should be based on the potential suitability of land in order to evaluate the suitable sites of water harvesting and minimize the soil degradation by selection of proper techniques of soil conservation to reduce amount of runoff.

The general objective of the study is an improved agricultural production in the study area using (GIS) and remote sensing which increases efficient utilization of rainfall through proper water harvesting planning. Specific objectives include:

1) Identification of potential areas which are suitable for given methods of water harvesting.
2) Identification of potential areas which are suitable for given type of soil conservation techniques with it is suitable land use.
3) Study the effect of soil conservation techniques and water harvesting technique on the amount of runoff.

Literature Review

Water harvesting is the collection and concentration of runoff water for the production of food crops, pasture and trees, for livestock or domestic purposes. All water-harvesting systems comprise catchments (sources of water) areas and storage components.

The most important factors to be taken into consideration in establishing a water harvesting project are rainfall distribution and intensity, runoff characteristics of the catchments, soil depth, physical properties of cultivated area, reservoir capacity, social and economic condition of farmers (Shatanawi, 1995).

In semiarid regions and steeping lands, micro-catchments of various types can be built to reduce and collect runoff and increase infiltration along the slope. These micro-catchments commonly consist of diamond and semi-circular or crescent-shaped earth bunds constructed along the contour line. Water is impounded behind the bunds to the level of the contour, and eventually overflows to spread down into the next lower tier of the bunds (Finkel 1986).

The most important parameters to be considered in identifying areas suitable for rain and floodwater harvesting are as follows:

a) Rainfall: the knowledge of rainfall characteristics (intensity and distribution) for a given area is one of the pre-requisites for designing a water harvesting system. The availability of rainfall data series in space and time and rainfall distribution are important for rainfall-runoff process and also for determination of available soil moisture.

b) Land use or vegetation cover: vegetation is another important parameter that affects the surface runoff. From the studies in West Africa (Tauer & Humborg 1992) and Syria (Prinz *et al*, 1999) proved that an increase in the vegetation density results in a corresponding increase in interception losses, retention and infiltration rates which consequently decrease the volume of runoff. Vegetation density can be characterized by the size of the area covered under vegetation. There is a high degree of congruence between density of vegetation and suitability of the soil to be used for cropping.

c) Topography and terrain profile: the land forms along with slope gradient and relief intensity are other parameters to determine the type of water harvesting. The terrain analysis can be used for determination of the length of slope, a parameter regarded of very high importance for the suitability of an area for macro-catchments water harvesting. With a given inclination, the runoff volume increases with the length of slope. The slope length can be used to determine the suitability for macro or micro- or mixed water harvesting systems decision making (Prinz *et al*, 1999)

d) Soil type & soil depth: The suitability of a certain area either as catchment or as cropping area in water harvesting depend strongly on its soils characteristics viz. (1) surface structure; which influence the rainfall-runoff process, (2) the infiltration and percolation rate; which determine water movement into the soil and within the soil matrix, and (3) the soil depth incl. soil texture; which determines the quantity of water which can be stored in the soil.

e) Hydrology and water resources: the hydrological processes relevant to water harvesting practices are those involved in the production, flow and storage of runoff from rainfall within a particular project area. The rain falling on a particular catchment area can be effective (as direct runoff) or ineffective (as evaporation, deep percolation). The quantity of rainfall which produces runoff is a good indicator of the suitability of the area for water harvesting.

Water conservation methods, often referred to as in-situ rain water harvesting; include activities such as mulching, deep tillage, contour farming, terraces and ridging (Habitu and Mahoo 1999). Conservation technologies can reduce soil and nutrient losses, and in this way preserve water holding capacity and soil fertility, and make possible sustainable crop production. In many instances, the use of conservation technologies may increase crop yields by 50% (Pimented *et al*, 1995.). In steep land farming, physical structures such as rock barriers, contour bunds, waterways (diversion ditches, terrace channels and grass waterways), stabilization structures (dams), windbreaks, and terraces (diversion, retention and bench) are often necessary (Morgan 1986).

Land use/ land cover information is the basic pre-requisite for land and water resources utilization, conservation and management. The information on land use/land cover available today in form of thematic map based on electro magnetic energy from the sun which is reflected scattered or emitted by different surface feature on earth. Earth feature such as water, forest, exhibit, typical spectral response pattern that enable for target identification.

A land suitability evaluation is carried out based on some critical land quality parameters, which determine the suitability of the land for a certain use (Chen *et al*, 2003). The framework for land evaluation developed by the FAO has over the years become a much utilized basic system for assessing the current and potential suitability of different land use alternatives (FAO, 1976). In a project which aims at using the FAO system, one of the most important issues is to determine which land properties (land qualities and land characteristics) are most limiting for production. The criteria for rating the limiting biophysical land properties have mainly been developed from measurements and calculations. The properties chosen depend on the time allowed for the project, its scale (size of the project area and intensity) and finance. In order to reduce costs, measurement are often limited to a minimum and much of the establishment of criteria ranking is based on results from other areas of a similar kind and on the experience of the survey team. For each property chosen an error may be introduced when extrapolating the results on the three – dimensional model (maps). The sum of the errors for each property may, in turn, result in a more or less uncertain final suitability evaluation (Messing and Hoang, 2001).

Owis *et al*, (1995) found that about 12% of the target land area (AWNA-Aleppo) is not suitable for any type of water harvesting. However, about 68% is found generally suitable, out of which 24% is favorable for the application of a macro-catchments water harvesting system.

Geographic Information Systems can be defined as computer based tools that display, store, analyze, retrieve, and generate spatial data. GISs are being more and more involved in hydrology and water resources and showing promising results.

A watershed is defined as a catchment basin, which is delineated topographically and drained by a stream system; it is a hydrological unit used for the planning and management of natural resources (Brooks *et al*, 1997).

A Digital Elevation Model was used to model the effects of land topography in the watershed delineation by identifying the streams, flow direction and a catchment perimeter or that portion of the land that affects a given outlet (Maidmont, 1993).

One method of transforming the rainfall volume into runoff volume is the US Department of Agriculture, Soil Conservation Services (SCS) runoff curve number (CN) method (SCS, 1972). This method is known for its simplicity. The CN is an index based on physical parameters of the watershed. It can be applied to gaged as well as ungaged watersheds. This method is able to reflect the effect of changes in land use on runoff. The CN is determined from a combination of land use and soil runoff potential (hydrologic soil group). CN values range between zero and 100. A value of 100 indicates that all rainfall is transformed into runoff (no abstractions), while for CN equal to zero, no direct runoff is generated.

General Description for Study Area

The study area extends from the western part of AL-Salt near Kufur Huda to King Abdullah Canal (KAC) in the Jordan Valley. It is unpopulated area and includes many hills. Many dendrites wadis are also present in the area such as Wadi Abu El-shananir, Wadi Um-Butmah and Wadi Dafali. The slopes of these wadis are directed from NE-SW to reach (KAC).

The area shows an oval shape with its longest axis in the E-N direction. The elevation increases from 200 m below the mean sea level near KAC to 142 m above the mean sea level at Rujm el-Mintar and 437 m at the upper northern part of the area near the main road. The slope reaches about 8 % in most of the areas, but it exceeds this value in many areas such as EL-Hawieh and wadi El-Shananir where it reaches about 20%. Many springs are located in the area such as: Ain UM El-Shananir and Ain UM Taineh. All these spring are contact-fault springs discharging their water from the sandstone.

Dafali Catchment Area

Wadi Dafali Catchment Area is located at the eastern part of the Jordan Valley between the grids 373,600 to 375,100 East and 551,100 to 552,410 North (Fig. 1). The generally oval shaped area with its longest axis in a NE-SW direction comprises about 1.6 km2. The longest wadi extends for 2 km and dips in the direction of the springs. The catchment area is characterized by a dendrite drainage system, with highest elevation at 435 m above sea level at the north and the lowest point at 250 m in the south. The dominant aquifer system is the Kurnub Sandstone.

Methodology

Methods:

1- Identification of suitable sites of water harvesting

1- Land evaluation will be done according to FAO framework for land evaluation (FAO, 1976). Digital soil map of 1:50000 scales produced by the national soil map and land use project of the ministry of agricultural, (1993) will be used and loaded in Arc/view-GIS software.

2- The land utilization types will be used:

1- On-farm water harvesting for tree crops.

2- On-farm water harvesting for forage shrubs or improved range

3- Runoff areas.

NSMP aggregated required land qualities and their land characteristics into five main groupings: Climate, Soil, Erosion, Topography and Rockiness. The requirement of each land utilization type will be compared with land attributes derived from each land-mapping unit, resulting in the land suitability classification for each use, based on classification approach of the FAO framework for land evaluation. In this step a Geographic Information Systems (GIS) will be used in order to integrate the data from different sources into one coherent whole. Point in polygon analysis will be used to undertake the suitability analysis. GIS will be also used to produce land suitability maps.

2-Identification of potential areas which are suitable for given type of soil conservation techniques

The FAO criterion of soil conservation techniques in humid region will be used to select the suitable site of different type of soil conservation techniques. The GIS will be used to measure the slope division according to the criteria needed for all type of techniques. Match the land use and land cover of the study area with the land use of every type of terraces and for unused land give the suitable site of terraces with it land use.

3- Study the effect of soil conservation techniques and water harvesting technique on the amount of runoff

1- Delineate the Wadi Dafali Catchment which locate in the study area by WMS (water modeling system) using contour map with scale 1:5000 to find the boundaries of catchment.
2- Classification of hydraulic soil group (HSG's) according to their minimum infiltration rate. Digital soil map of 1:50000 scales produced by the National Soil Map and Land use Project of the ministry of agricultural, (1993) will be used and loaded in Arc/view-GIS software.
3- Digital Landsat Enhanced Thematic Mapper imageries taken from different dates will be used to derive the land use/ land cover maps of the watersheds.

4- Field surveys will be conducted for different geographic sites along the entire watershed to identify some land use/ land cover classes such as urban, agricultural, wetland, road and others.

5- The curve number CN will be obtained from standard tables of Soil Conservation Services (SCS) for different combinations of land use and land cover, soil hydrologic group, treatment, and condition.

6- Measured the amount of runoff using the equation:

$$P_e = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Where:
P is the rainfall depth (mm).
P_e is the depth of excess rainfall (mm).
I_a is the initial abstractions (mm).
S is the volume of total storage (mm).

$I_a = 0.2S$

$$S = \frac{25400}{CN} - 254$$

Where CN is the curve number.

7- Estimate the amount of runoff after we change the land use for every of technique of water harvesting and conservation using WMS and compare them by the real amount of runoff.

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2004 Annual Progress Report- Middle East Watershed Monitoring and Evaluation

1. Progress

Watershed Level Monitoring

Erosion and sediment monitoring:

The primary objectives for monitoring in the Upper South Platte watershed for 2004 were to: (1) continue monitoring site conditions and sediment production from the existing control and thinned sites; (2) continue monitoring road segment conditions and sediment production from roads in burned and unburned areas; (3) establish Jenny Gulch for monitoring the effects of thinning on ground cover and sediment production; (4) determine the effect of forest thinning on soil moisture; and (5) determine the effect of litter cover on sediment production.

In each site an Onset or a Global Water tipping bucket rain gauge with 6-inch collection openings was installed. Data were screened for quality control and bounce back tips were eliminated. Corrected data were analyzed using RF, a tool for calculating the Revised Universal Soil Loss Equation (RUSLE) R factor (Petkovšek, 2005). Individual storms were defined as being over 1 mm of precipitation and were separated by a 60-minute period with no precipitation. Outputs from RF included storm depth, maximum 30-minute intensity, energy of rainfall, and total erosivity, which was calculated using Brown and Foster (1987) energy equation. Thirty (30)-minute rainfall intensities were classified into recurrence intervals using Hershfield (1961).

Swales were selected at each site based on the presence of three main criteria: (1) well-defined boundaries; (2) slopes between 10 and 40 percent; and (3) presence of a proximal swale to be used as a pair. After the qualifying pairs where chosen, one was randomly selected for treatment. The controls were protected from the thinning operation while treated swales were left unmarked.

Independent swale characteristics such as area, gradient, aspect, and ground cover composition were measured. The areas of the swales were determined with a measuring tape and evenly spaced transects. The primary and secondary gradients were determined with the use of a handheld clinometer, and the aspects were determined with a compass. Ground cover was measured with the use of point-counts and an adaptation of the method established by Parker (1951).

Ground cover differences between treated and control swales were tested prior to thinning, within one year of thinning, and within two years of thinning between controlled and thinned swales. The difference in ground cover between years was not tested due to the large difference in precipitation, which greatly affected the amount of vegetation present on the ground. Prior to 2003 ground cover measurements were separated into bare soil, litter and downed wood, rock, and vegetation. The 2003 to 2005 ground cover measurements were separated into the same categories with the exception that litter and downed wood were two unique classes. Ground cover data were not available for Denver Water and Jenny Gulch sites prior to thinning due to the lack of preparation time before thinning.

The percent of ground disturbance for each swale was recorded after the mechanical thinning. This was determined with a point-count method conducted concurrently with ground cover survey. Each point was classified as severely disturbed, moderately disturbed, or undisturbed, similar to the classes used by Heede (1986). The severely disturbed class included any point that had soil displaced by machine tracks, tires, feet, or any other mechanical means. The moderately disturbed class included any point that had litter added or removed, but did not appear to have disturbed soil. The undisturbed class included any point that had natural ground cover and soil that had not been changed by mechanical means.

Sediment production from each swale was monitored through the use of sediment fences, a method modified from Dissmeyer (1982). Sediment trapped by the fences was manually removed and weighed, a sample was taken from each bucket of sediment and placed in an airtight bag, and this sample was weighed and dried at 100 °C for 24 hours. The moisture content of the sample was then used to normalize the mass of the sediment removed from the fence to obtain dry sediment mass.

Soil moisture was measured in three swale pairs in Bear Mountain and two swale pairs in Jenny Gulch over the summer-2004 with the use of a time domain reflectometry probe (TDR). Three five-centimeter prongs were chosen for the TDR probe to make probe insertion into the coarse soils possible. The moisture was monitored at fifty points within each swale. These points were marked by ground flags place in five transects. The measurements were taken from a different side of the ground flag on June 13, July 8, July 27, and August 24, 2004 to prevent disturbance of the soil column.

The data were analyzed for significance between control and treated swales, measurement dates, transect locations, and elevation of measurement point. Analysis was done using a mixed model in the statistical program “SAS”.

Three swale pairs at the Trumbull site were used in the litter manipulation study. Ground cover counts were performed on the swales. One swale from each pair was randomly selected, and litter was removed using plastic lawn rakes and large geo-textile fabric bags in June 2004. Live vegetation was not removed and downed logs were left in place. Litter was placed into bags, weighed, carried outside of the swale boundary, and dumped. Samples were taken to correct for moisture content. Cover counts were performed again on the denuded swales to measure the difference in cover. Sediment fences were previously installed at the base of the swales and were left to measure the difference in sediment production between the control and denuded swales.

In summer 2004 the contributing area and percent cover of the contributing road area were re-measured for the existing sites with sediment fences. This was done with point-counts and measuring tapes similar to the method used for the swales. At the same time the functionality of the fences was assessed and nonfunctional road fences were abandoned or replaced. No new fences were installed in 2004. Eroded sediment from the segments was measured with the same method as the swales.

Results

Mechanical thinning was conducted at five different sites, mostly during the winter months over a four-year period. In 2004 there were 20 thinned and 20 control swales monitored (Table 4). Thinning was done by a Hydro-Ax, which is a large skidder with a rotating blade attachment. These masticate trees leaving small chip particles and large log particles. On four sites the Hydro-Ax ran on rubber tires either with or without chains. The Hydro-Ax used on the Denver Water site had caterpillar tracks.

Swale size varied between swale pairs and between sites. The largest average swale area was at the Spring Creek site (6500 m^2) and the smallest mean area was at the Trumbull site (940 m^2). Swale slopes also varied from pair to pair as the steepest swale had a slope of 55% and the flattest was 10%. The Kelsey swales were destroyed from the thinning process. Some of these control swales in Kelsey were thinned and some treated swales were not completely treated. As a result Kelsey was not monitored after thinning.

The only significant change in ground cover over the entire study after thinning was an increase in wood cover. Prior to thinning there were no significant differences in ground cover between the control swales and the swales designated for thinning at the ($p>0.05$). Thinning increased the amount of surface cover due to wood from 3.6% to 6.7% within one year after thinning, and this difference was significant at $p=0.05$. The thinned swales still had significantly more wood cover two years after thinning. If the data are analyzed by study area the Trumbull and Denver Water sites had no significant differences in ground cover prior to thinning, while the Bear Mountain site had significantly more wood cover in the control swales than in the thinned swales ($p=0.034$). After thinning the percent wood cover was significantly higher in the thinned swales in Trumbull, Denver Water, and Spring Creek, but not at Jenny Gulch ($p=0.079$). At Bear Mountain thinning changed the significant difference in wood cover to an insignificant difference showing an increase from pre-thinning ($p=0.891$). Jenny Gulch was the only site that had significantly less vegetation on the ground in its thinned swales than the control and this difference disappeared when combining it with other sites (0.006).

The treated swales had significantly more severely and moderately disturbed area than the control swales ($p=0.003$ and 0.001). The control sites had a small percentage of moderately and severely disturbed area at 7.8% and 5.8%. In contrast, the thinned swales had roughly four times the amount of moderately and severely disturbed area at 32.6% and 21.3%. The disturbance on the control swales was caused by either humans or animal tracks, or debris thrown by the Hydro-Ax. If the data were analyzed by study area, all areas had significantly more severely and moderately disturbed area in the thinned swale than in the control swale except Bear Mountain which did not have significantly more severely disturbed area in the thinned than in the control ($p=0.535$) possibly due to the more well developed soil which tended to have a thicker litter layer.

The thinned swales had significantly fewer trees and a larger mean diameter at breast height (DBH) than the controls. The number of stems per hectare decreased from 650 to 200 ($p<0.0001$) and the DBH increased from 18 to 28 cm ($p<0.0001$).
Despite the increased in precipitation, the disturbance, and the decrease in tree cover, no sediment was produced from any of the thinned or the control swales in 2004.

Statistical analysis of the soil moisture revealed five significant covariates. The site of the measurement significantly affected the soil moisture ($p=0.0277$). Soil moisture was elevated at Bear Mountain compared to Jenny Gulch. The date of the measurement significantly affected the soil moisture ($p=0.001$). The first monitoring date was the driest and the third date was the wettest. The treatment of the swales significantly affected soil moisture ($p=0.05$). Control swales continually had less soil moisture than the thinned swales. Along with these three main covariates, date*site and date*treatment were significant interactions. The date*site revealed that Bear Mountain and Jenny Gulch did not exhibit the same soil moisture trend over the four measurement dates. The date*treatment interaction revealed that the magnitude of soil moisture difference that existed between the thinned and the control swales changed depending on the measurement date. A general relationship between the soil moisture and the precipitation is evident. In contrast to the soil moisture difference, precipitation is relatively similar between the two sites. Jenny Gulch recorded 29 mm of mean precipitation 2 weeks prior to measurements and Bear Mountain 31 mm of mean precipitation. One week prior to the measurements Jenny Gulch even recorded a higher mean precipitation (11mm) than Bear Mountain (10mm).

The 12 Spring Creek fences, the 3 Nighthawk fences, and the 2 Kelsey fences were functional and no new fences were installed at these sites. One of the two road fences in Upper Saloon Gulch was only detaining sediment from a ditch beside the road and no data were collected from this fence. In Trumbull, many fences were still collecting sediment, but the flow was partitioned between multiple fences. These fences were maintained, but the data was not comparable to fences that are collecting flow and sediment from one fence exclusively.

Each of the functional road fences trapped sediment in 2004 and the total mass of the dry sediment was 32,000 kg. The mean sediment production rate from all sites was 5.3 kg m^{-2} yr^{-1} and the range was from 0.8 kg m^{-2} yr^{-1} at Kelsey to 6.8 kg m^{-2} yr^{-1} at Spring Creek. The maximum sediment production rate was 16.3 kg m^{-2} yr^{-1} for a segment in Spring Creek.

In the original project design, changes in runoff as a result of thinning were to be evaluated by comparing flows from the Saloon Gulch catchments, which was to be treated, in Brush Creek. In early summer 2002 76-cm H flumes were installed in each basin, but approximately 50% of each watershed was burned at high severity in the Hayman wildfire. Runoff and erosion rates increased by several orders of magnitude after the fire and resulted in the Saloon Gulch flume getting completely buried by sediment. The Brush Creek flume filled with sediment and organic debris during each runoff event. This flume was excavated twice in summer 2003 with the hope that the flume would remain free of sediment during subsequent runoff events, but the continuing accumulation of sediment and organic debris from each runoff event is precluding the collection of discharge data.

Baseline runoff and water quality measurements were made on an approximately monthly basis on No Name Creek in the Trumbull area and Saloon Gulch in 2001 and 2002, and channel characteristics were measured each year. Again the goal was to evaluate whether thinning would alter water quality or channel characteristics. As expected, water quality in Saloon Gulch greatly decreased after the Hayman fire, and there was considerable sediment deposition and a marked decrease in bed material particle size. No Name Creek was not affected by the Hayman or Schoonover fires, and the resurvey of two cross-sections in 2003 showed little to no change relative to previous surveys. Neither discharge nor water quality were measured in 2004, but both the literature (MacDonald and Stednick, 2003) and the absence of any erosion at the hill slope scale indicate that thinning should have little effect on either water quality or channel characteristics.

Discussion

There was more summer precipitation in 2004 than any of the previous 3 years of monitoring. The intensity at Nighthawk reaches the 25 year return interval. Nevertheless, none of the 20 thinned swales and none of the 20 control swales produced any sediment in 2004. These results indicate that the thinning activities being conducted in the Upper South Platte River Watershed are <u>unlikely</u> to increase erosion rates except under the most extreme rain events.

There are numerous factors that effect soil moisture such as the quantity of evapotranspiration, precipitation, and the soil characteristics. In this study two soil types were used to study the effects of thinning on soil moisture. The results show that in the summer months the surface soil moisture is elevated in the thinned swales compared to the control swales. The probable cause of this increase is the decrease in transpiration and interception from the canopy. But, there are other processes that affect the soil moisture such as the increase in wood to the ground cover, the increase in wind turbulence, and the increase in solar radiation on the ground surface. The quantity and importance of these factors are unknown. This study was designed to detect a difference in the soil moisture; more information is needed to determine the longevity of the soil moisture increase and the fluctuation due to seasonal variability. After the longevity and fluctuation of the soil moisture increase are known, a process study would be helpful to determine if this effect would be seen in other climates or environments.

The result of the litter removal was surprising. When raking the swales, many coarse soil particles were collected with the litter. This caused the weight of removed litter to be greater than it should have been. The rakes also did a poor job at collecting all litter sizes. Many small litter pieces were left on the swale. These small litter pieces were available to absorb energy which otherwise could be used to move soil particles as a result of rain splash. Similarly the rake left vegetation, such as kinnikinnick, behind. Finally, the rainfall intensity over these swales was very low and may not have been sufficient to initiate erosion regardless of the treatment. Further monitoring is needed to see what rainfall is needed to initiate erosion on these denuded slopes.

In contrast to the swales, all of the road segments continued to produce sediment. The mean sediment production rate of 5.3 kg m^{-2} yr^{-1} is at least as large as the 2001, 2002, and 2003 means of 2.1 kg m^{-2} yr^{-1}, 0.4 kg m^{-2} yr^{-1}, and 2.7 kg m^{-2} yr^{-1}, respectively. This could be a result of increased use from heavy logging equipment or a result of increased precipitation and precipitation intensity.

All roads are on the Sphinx soil series with the exception of Trumbull, which is on the Kassler series. The road fences in Trumbull also are unique because some do not catch all of the drainage from one segment, while others catch all of the drainage from one segment plus some runoff from upslope segments. Because of these two reasons, Trumbull road fences will be analyzed separately.

Conclusions

Forest thinning at this intensity level does not increase hill slope-scale sediment production rates from rain events ranging up to the 25-year storm. Thinning increases the percent wood cover on the ground, the summer surface soil moisture, and the percent of moderately and severely disturbed ground, and the mean DBH of the trees within a swale. Continued monitoring of these effects are valuable for determining the longer-term effects of thinning on surface vegetation, the precipitation needed to initiate erosion from thinned and undisturbed swales, and the persistence of the increase in soil moisture. Changes in water quality and channel characteristics are unlikely, and the monitoring at this larger scale has not shown any effects due to thinning and burning.

Unpaved roads continue to be the dominant source of sediment in unburned areas. The data collected since 2001 will be used to develop a model to predict sediment production from forest roads in the Upper South Platte Watershed. This model can be applied to other areas.

2. Personnel Changes. Two students from Colorado State University were made available on an as needed basis for project monitoring.

3. Travel. No in-country travel occurred except for travel to and from the project area.

4. Meetings and Collaboration. The United States hosted the 2004 international meeting in Lakewood, Colorado in July. Members of the international study team from

Turkey, Jordan, Israel, Palestine, and the United States participated in this event. The United States also hosted a tour of the Upper South Platte watershed for the team members. This watershed is the United States' M.E.R.C monitoring study area.

5. Publications. One document was published.
Libohova, Z., Effects of Thinning and a Wildfire on Sediment Production Rates, Channel Morphology, and Water Quality in the Upper South Platte River Watershed, Fort Collins, Colorado, Spring 2004.

If you have any questions concerning this Progress Report, please feel free to contact either Steve Culver or Fred Patten on the South Platte Ranger District at 303-275-5610

Annual Report
Watershed Monitoring and Evaluation Project
Palestinian Authority – College of Agriculture
Hebron University
Period covered: January, 1, 2004 – December,31 , 2004

In our pioneer project (Watershed Monitoring and Evaluation Project), many new aspects have been investigated thoroughly that related to water harvesting in arid and semi-arid regions. There are many water harvesting techniques that were used all over the world, and in our project, generally, we are going to study the best evaluation and monitoring method for these techniques.

During the fourth year of the project life many activities have been accomplished related to the project work and many results were obtained from the data collected about the different aspects of vegetation, soil, and runoff. The following are the main project activities that executed during the past year:

- **International study team meeting:**
  The annual meeting for the international study teem was conducted in Colorado-USA. The agenda for the meeting was very intensive that includes the achievements, obstacles, data presentation, and future plans. The meeting was very fruitful. Many notes and suggestions were provided by the study team members about the works of every partner and about the project in general. Each partner gave a presentation about his work. A special section was held for the future project activities (during the fifth year) and put more attention on coordinating the type of data that had been collected and that will be collected during the fifth year.

- **The study sites:**
  It was planned that a new study sites will be included, in addition to increasing the areas of the current sites. During this period, more area was included in the project activities. The basic works in the old and new sites were completed according to the project plans, as following:
  - Sorif site: more area was added to the study site. Stone terraces and soil half moon structures were established. Many micro catchments were built in the site according to the treatment for runoff and soil sedimentation data collection. The fruit trees were planted in the site (mainly almond) for further evaluation. Several medicinal and herbal plants will be planted during the coming weeks. Old forested area was also added to the project site, and different data will be collected about vegetation, soil erosion and sedimentation, and runoff.
  - Dura site: A new land was added to the study near the old site, where stone terraces and soil half moon structure were also established. Medicinal plants and herbal plants will be planted in the site during the next few weeks.
  - Bani No’em site: In addition to the works that already done in Bani No’em site, a new area was prepared by building contour soil furrows and planted with fruit trees.
  - Zeef site: Some works started in this site, mainly fencing, and we hope that the work will continue in this site during the coming period.

- **Data collection:**

  Although the political situation during the summer months (mainly September and October) was very dangerous and there was a complete siege around Hebron city, we are lucky to collect all the required data and do the necessary site preparation on time. Giving that the vegetation, runoff, and sedimentation data were already collected during the winter and spring season, only part of the soil data was collected during the summer months. The unrest situation affects mostly on delaying the preparation of the new site for the coming winter, that includes building the necessary water harvesting structures, and building the micro catchments.
  The necessary soil samples from each treatment at each study sites were regularly collected according to the plan and transported to the lab. The physical and chemical soil analysis is in process.
  While collecting the vegetation, soil, and runoff data from the different treatments and techniques, the time (man hour) and labor were also recorded to evaluate and compare the different methods used for water harvesting. Summery for part of the data are shown in Appendices B and C.

- **Vegetation study:**
  The preparation for more vegetation study at the current study sites was completed, that will put more attention on the spices, medicinal plants, and fruit trees as it was planned in the supplemental vegetation study. A master student already started her theses on this part. Several important spices and medicinal plants were determined to be under investigation in relation to the environmental conditions and the water harvesting techniques as it was planned in the supplemental vegetation study. The works will include plants that grow naturally and others replanted at the study sites (mainly the new sites).
  The influence of type of vegetation cover (natural vegetation, natural without *Sarcopoterium spenosum,* old forest, new planted forest, and cultivated land) on soil erosion and runoff will be also evaluated.

- **Master students:**
  Four master students now works within the project, one of them (Osama Al-Jo'bih) is expected to be graduated during the coming spring semester. Mohammad Al-Adum is a new master student added to the project team at the beginning of Fall semester.
  (Appendices B and C showed a summery for part of the works of Osama and Saleh for their theses).

- **Training course:**
  As it was discussed at the IST meeting, a training course will be conducted at Sede Boker with cooperation with the Israeli partner, were a group of student will share in this course during February, 2005. The course out line and the permits for the students are in process, and it will concentrate on practical training for some important aspects of water harvesting techniques and vegetation data collection.

- **Obstacles:**

As usual, the main obstacle is the current political situation. The continuous siege around the cities and closing the roads by the Israeli occupation restricts our movements, therefore, the project activities delayed and not accomplished on time and in many cases the works delayed for the next year. To solve this problem, we tried to found sites that are easy to reach, but not all the time this works out because the situation some time so difficult that movement and visiting the sites become dangerous. Therefore, non-cost extension for the project is essential for us to achieve the project goals.

- **Purchasing lab equipment and chemicals:**

To perform the necessary soil chemical and physical analysis, several lab equipments, tools and chemicals were purchased.

Summery for Purchased Equipment and chemicals

Number	***Item***	
	Chemicals	Set
	Water Deionizer	
	Fume Hood	
	Kjeldhal Unit and Accessories	
	Separation funnels	
	PH meter Electrode	
	Pipette stand	
	Measuring cylinders	
9	GPS	1
10	miscellaneous	

- **Budget expenditures**:

(See Appendix A for the financial report)
The main categories for budget expenditures were include:

- Salary for the technician, master students, workers.
- Travel.
- Constructions: terraces, micro catchments and fencing.
- Plants (seedling) and planting.
- GIS Consultant.
- Lab equipment and chemicals.

- **Future plans:**

Basically the work plans for the fifth and last year of the project life will be as it was set from the beginning of the project, taking in consideration the modifications and the additional works that was agreed upon during the IST

meetings. The usual vegetation, hydrology, and soil data will be collected. All partners were prepared tables about the variables under investigation in order to have comparable data between the partners.
More vegetation investigation will be made during the next period. Our work for this part will include additional works on several spices, medicinal plants and fruit trees. More area at each site was added to the study and the required preparation for data collection was completed, in addition, a new sites also added to the study.
The data collected during the life of the project will be analyzed and published in a scientific Journal in addition to the master theses.

Appendix B:

Osama primary results (master student)

Studies of Natural Vegetation Characteristics at Different Environments and Range Improvement Practices at Southern Part of West Bank

Introduction

Historically, Palestine was famous for its rich vegetal green cover and Species, also it is famous with its variety in climate, topography, and other environmental characteristics. This variety founded different plant Geographical territories exist in small area, and each geographical Territories represent one or more different ecosystem. Rangelands in West Bank serve as important watershed and represent a source of genetic and species diversity, and they represent renewable natural resources. These rangelands have been shaped by climatic variation, topography, cultivation, livestock grazing, and fire. These factors, and the neglecting of natural resources and the misused especially during the Israeli occupation caused a high rate of soil and land degradation, which led to disappearance of vegetation cover, decreased in vegetation productivity, increased in poisonous and unpalatable plants, severe soil erosion in many area where soil becomes shallow and infertile, and finally the threat of desertification. Therefore soil conservation and water harvesting is an essential steps in developing these rangelands.

Range improvement and development is the best insurance against land degradation, and will increase the watershed value. However, the basic information about the main factors of rangeland ecosystem in West Bank and their interactions are still lacking, and there are very limited scientific researches about natural vegetation community in West Bank. These scientific information are required to set up the suitable management and development plans.

Objectives

The overall objective of this study was to evaluate and assess different vegetation characteristics at Southern part of West Bank

The detailed objective for this study was to evaluate the change in plant botanical composition, biomass, density, and frequency as affected by the following factors:

1) Environmental factors
2) Excluded grazing.
3) Water harvesting techniques.

Material and Methods

Vegetation characteristics of the natural vegetation were evaluated at three different watersheds at Southern part of west Bank during the years 2003 and 2004 at different environmental factors and water harvesting techniques.

The study consists of three main field experiments to obtain the study objectives. The experiments were implemented at three sites in Hebron District at Southern part of west Bank.

Experiment one was aimed to determine and compare different vegetation characteristics under different environments. Data was collected from the three study sites(Bani-No'em, Dura, Sorif) which where different in rainfall, temperatures, and other environmental factors. For each site, plant composition, plant cover, plant density, plant frequency, and vegetation biomass were measured in one location that have been excluded from grazing, and compared between the different sites.

The aim of experiment two was to evaluate the effect of excluded grazing. Vegetation characteristics were evaluated and compared between grazed and ungrazed plots.

Experiment three was aimed to evaluate the effect of water harvesting techniques. Three water harvestings techniques was evaluated, Contour ridges in Bane-Noam site, Semi Circulars bunds in Sorif site, and natural vegetation as control in the three sites.

Contour Ridges was constructed a long the contour lines by moving the soil a long the line and placed down slope to form ridges. While Semi Circular bunds was constructed by forming a bunds a long the parameter of semi circle, with the tip of each bund are set on the contour.

Vegetation sampling was carried out in April and May during the peak development stage of plants, and vegetation characteristics was calculated as the following:

Ground Cover:

A one hundred step point method was used in one randomly transect, and whatever appeared below the tip of the boot was recorded (soil, rock, or plant by species), and the percent of soil, rock, and plant were calculated

Vegetation Biomass

At each treatment fifteen (1) m^2 quadrate was allocated randomly (used as replicated), and all the current year growth of each plant species inside the quadrate was clipped to the soil surface ,and placed in labeled paper bags. The plant samples were taken to the lab and the fresh and dry weight (dry at 65 C°) was recorded , and multiplied by a given factor to obtain biomass in Kg/ ha.

Plant density

At each treatment fifteen (0.25) m^2 quadrate was allocated randomly (used as replicate) in one transect. The number of individual of each species, and the number of all species was recorded**.**

Plant frequency

The presence or absence of each species in quadrate was calculated from density data.

Primary results:

In this study 118 species belonging to 23 families were recorded in the three sites. Results indicated that dry biomass was low in the three sites, 979 Kg/ha in Bane No'em, 2279 kg/ha in Sorif, and 2623 Kg/ha in Dura. The plant density for the three sites was, 646 plant/ m^2, 125 plant / m^2, and 124 plant /m^2, in Bane-No'em, Sorif, and Dura respectively. The most dominant species were, *Asphodelus aestivus*, *Poa bulbosa*, *Anthemis spp*, and *Erodium gruinum* in Bane-Noem site, *Avena sterilis*, Bromuse spp, *Hordeum spontaneum*, *Sarcopoterium spinosum*, and *Asphodelus aestivus* in Sorif and Dura Sites.

Grazing decreased the vegetation characteristics, and increased the unpalatable species such as: *Sarcopoterium spinosum*, *Asphodelus aestivus*, Thymelaea hirsute, *Varthemia iphionoides*, and Eryngium spp.

Data show that Water harvesting techniques alter the botanical composition of the vegetation. Plant density in the W.H.T plot was increased at Sorif site. Also W.H.T. increased dry biomass.

Table 1: Ground cover percentage (plant, soil, rock) at Bani No'em, Sorif and Dura sites during 2003 and 2004.

Percent ground Cover

	2003			2004		
Site	Plant	Soil	Rock	Plant	Soil	Rock
Bani-No'em						
Natural vegetation	88	5	7	95	2	3
Grazing	79	9	12	54	27	19
Contour Ridjes	95	3	2	96	4	0
Sorif						
Natural Vegetation	78	9	13	94	2	4
Grazing	62	14	24	62	22	16
Cresent	---	---	---	93	5	2
Dura						
Natural Vegetation	---	---	---	92	5	3
Grazing	---	---	---	53	27	20

Table 2: Plant biomass (kg dry weight/ha) and plant density (no, of plants/m²) at the three study sites during the years 2003 and 2004.

	Dry Biomass (Kg/ha)		**Plant Density (plant/m2)**	
Site	2003	2004	2003	2004
Bani-No'em				
Conserved	945	978	745	646
Grazing	395	314	125	103
Contour Ridjes	651	1364	203	376
Sorif				
Natural Vegetation	3104	2279	218	125
Grazing	1353	356	191	36
Cresent	-----	2445	-----	303
Dura				
Natural Vegetation	----	2623	-----	124
Grazing	-----	281	-----	57

Table 3: Changes in plant growth (estimated by plant biomass and plant cover) during the growing season of 2004 year at the three study sites.

Biomass(kg/ha)

Bani No'em

Treatment	06-Jan	28-Jan	18-Feb	10-Mar	04-Apr	03-May
Conserved	18	70	410	899	978	738
grazing	196	120	216	198	314	298

Dura

Treatment	19-Jan	09-Feb	01-Mar	27-Mar	08-Apr	10-May
Natural vegetation	376	830	1117	2974	2623	1742
Grazing	64	684	563	764	281	196

Sorif

Treatment	05-Jan	26-Jan	24-Feb	20-Mar	14-Apr
Natural vegetation	785	830	1350	3809	2279
Grazing	610	962	1605	1824	256

Plant Cover (%)

Bani-No'em	06-Jan	28-Jan	18-Feb	10-Mar	04-Apr	03-May
Conserved	21	50	73	84	98	90
grazing	38	49	56	57	54	61
Shrubs	43	71	74	87	89	88

Dura

Treatment	19-Jan	09-Feb	01-Mar	27-Mar	08-Apr	10-May
Natural vegetation	59	71	82	94	92	93
Grazing	47	61	80	75	53	65

Sorif

Treatment	05-Jan	26-Jan	24-Feb	20-Mar	14-Apr
Natural vegetation	71	80	79	91	94
Grazing	50	73	73	75	62
Trees	52	83	81	87	79

Table (4) Dominant Species in Water harvesting treatment at Bane-No'em during 2004.

Species	Relative Density (%)	Relative Biomass (%)	Cover (%)	Frequency (%)
Bromus spp	19.2	16.7	7	73
Onobrychis caput-galli	1.8	1.6	8	60
Chaetosciadium trichospermum	9.7	4.9	5	80
Crepis aspera	2.7	2.6	4	47
Trifolium spp	10.2	6.5	13	53
Sinapis alba	2.2	8.6	10	60
Sarcopoterium spinosum	0.21	17.3	5	6.7
Hordeum marinum	29.2	26.5	4	87
Anthemis palaestina	2.4	0.8	3	60
Total	77.6	85.5	59	-

Table (5) Dominant Species in Water Harvesting treatment at Sorif site during 2004.

Species	Relative Density (%)	Relative Biomass (%)	Cover (%)	Frequency (%)
Avena sterilis	18.2	12.2	13	93
Aeglibose spp	19.4	2.8	8	60
Evax contracta	3.9	0.07	4	26.7
Trifolium spp	33.6	11.1	17	86
Sarcopoterium spinosum	1.2	57.3	15	73
Crupina crupinastrum	6.86	4.7	7	46.7
Total	83.2	88.2	64	-

Appendix c

Primary results of Saleh study (master student)

The influence of different water harvesting techniques on soil characteristic and there role to reduce soil erosion and runoff.

Introduction

Land degradation by the soil erosion, runoff, and sedimentation, are the serous problems facing the arid and semi-arid regions in West Bank. As a result of these problems soil tend to degraded, causing low soil fertility , in addition of the over exploitation of natural resources for agricultural production .

Soil and water conservation management by different water harvesting techniques, is an effective principle to reduce the high intensity of runoff , and subsequently increasing soil moisture storage from rainfall , while maintaining low level of soil erosion and sedimentation.

One of the studies in this field is

The influence of different water harvesting techniques on soil characteristic (physical and chemical properties) and there role to reduce soil erosion and runoff.

The study begins in 2003/2004 and be continuing in 2004/2005.

Objectives:

***** Three experiments will be established to achieve the following objectives:

- **I.** Study the influence of different water harvesting techniques on soil characteristics (physical and chemical characteristics).
- **II.** Study the effects of different water harvesting techniques on soil erosion and runoff.
- **III.** Study the effects of different water harvesting techniques on soil moisture regime.

Methodology

Three study sites are located in semi-arid regions of Hebron district (Bani-No'em, Dura, and Sorif) were choosed for the study. The following Deferent water harvesting techniques were constructed in these regions to achieve the study objectives;

- Stone terracing.
- Half-moon water harvesting techniques.
- Contour ridgs water harvesting techniques.
- Trees and shrub planting.

To achieve the first objective, three replicates of representative soil samples are taken from 0-10 cm of soil depth for each water harvesting techniques treatments. All soil samples from the three locations were taken to the laboratory for chemical and physical analysis. The bulk soil samples were air dried, crushed with a mortar and pestle, and sieved to remove coarse (>2 mm) fragment to be prepared for the analysis. The primary results for 2003/2004 are shown in Table (6, 7, and 8).

To achieve the second objective (measure surface runoff and sedimentation). Tow micro-catchments units of 50 m^2 in each treatment were built, Water tanks were also installed at the outlet of each unit to collect the running water and the sedimentation. The amounts of surface water runoff are measure after each rainfall events, the primary results for 2003/2004 are shown in table (1, 2, and 3), and also the cumulative sedimentation was measured at the end of the rainy season, the results shown in table (5).

The soil erosion measured by:

- Four Metal bars were placed at a marked soil depth in each treatments, to measure soil erosion at the end of the rainy season.
- Soil bioassay : its indirect method used to indicate how the soil erosion and runoff effects on nutrient leaching, to achieve this objective, One representative soil sample was collected from each treatments from the top 10 cm, in each locations (one from low slope , and one from up slope). Six replicate pots from each sample were prepared, three of them planted with corn, and the other three planted with bean, the difference in dry weight of the shoot and root between the treatments will be measures, and also some nutrient deficiency in plants will be measures, as an indicator for the soil erosion.

To achieve the third objective (soil moisture regime). Six replicate soil samples were taken from each treatment at each site. Soil samples were taken from different depths, at 15 and 30 cm deep in treatments with shallow soil, and at 15, 30, 50 and 60 – 75 cm in treatments with deep soil horizons. The samples were taken in cans to the lab to measure the water content and dried at 105 C^0, sample taken every 15 days beginning from 1/4/2004 until the 1/10/2004. The process will be repeated in 2005. Primary results is shown in table (4).

In addition to above measurements some plants performance will be measure as height, diameter of the stem and width, for different types of plants (olive and almonds) that planted in half-moon and v-shape water harvesting techniques, the objectives of this experiment is to show how these plant affected by water harvesting techniques.

Table (1) Water runoff (liter) in the different water harvesting treatments at Sorif site during the 2003/2004 winter season.

	Date of data collection								
Treatments	**16.12.03 (36)***	**22.12.03 (58.5)**	**17.1.04 (137)**	**24.1.04 (8)**	**9.2.04 (26)**	**17.2.04 (36.5)**	**24.2.04 (19.5)**	**20.3.04 (21.5)**	**Total runoff (343)**
olive tree	26.5	67.75	692.8	3.8	11.3	29.2	15.1	28.8	875.3
Shrubs	19	56.5	158.2	0	9.1	24.5	9.5	3.7	270.5
Terracing	11.3	37.6	357.6	0	64	2.88	1.9	0	475.3
Na. veget	22.6	45	670.2	15.1	30.12	45.18	30.12	11.3	869.6
Halfmoon	30.1	61.7	591.1	0	22.6	45.18	15.1	5.66	771.4

∗ Amount of precipitation (mm) during that period.

Table (2): Water runoff (liter) in the different water harvesting treatments at Bani No'em site during the 2003/2004 winter season.

	Date of data collection							
Treatments	**22.12.03 (74.3)***	**17.1.04 (100)**	**24.1.04 (8.5)**	**28.1.04 (12.5)**	**8.2.04 (24.3)**	**18.2.04 (55.5)**	**10.3.04 (15.7)**	**Total runoff (290.8)**
Na. veget	165.63	293.8	0	15.1	131.89	45.18	15.1	666.7
Terracing	26.36	353.5	0	0	0	72	0	451.9
Tree	38	94	8	0	38	60	11	249.0
Soil trracing	68	94	4	7.53	41	36	25	275.5

∗ Amount of precipitation (mm) during that period.

Table (3): Water runoff (liter) in the different water harvesting treatments at Dura site during the 2003/2004 winter season.

	Date of data collection							
treatments	**22.12.03 (47.9)***	**17.1.04 (101.3)**	**24.1.04 (5.2)**	**6.2.04 (41.8)**	**20.2.04 (21.5)**	**23.2.04 (15.5)**	**8.3.04 (11.3)**	**Total runoff (244.5)**
tree	30.12	354	0	124	117	105	9	739.1
terracing	30	196	0	40	23	19	0	308.0
Na.vegat	56	215	0	47	32	23	0	373.0

* Amount of precipitation (mm) during that period.

Table(4) : Preliminary data for changes in soil moisture during April/2004 at the study sites.

Sites	**Percent soil moisture**		
Sorif	**1-3 / 4 / 2004**	**18-20/4/2004**	**3-5/5/2004**
1-Natural vegetation*	15.31	13.63	13.5
2- Terracing **	18.49	14.65	14
3- Olive tree **	16.24	14.05	13.71
4- Half-moon**	15.35	13.51	12.6
5- Grazing *	8.57	7.75	6.65
6- Shrubs*	15.61	14.93	14.40
Ban noem			
1-Natural vegetation*	7.80	7.66	6.41
2- Terracing**	19.28	17.68	16.24
3- Tree **	12.31	10.57	10.39
4- Contour rigs**	11.44	10.86	10.2
5- Grazing *	7.62	7.24	6.99
6- Shrubs*	9	7.24	7.5
7- Forest**	12.20	9.69	9.50
Dura			
1-Natural vegetation*	8.15	8.35	8.01
2- Terracing**	14.56	15.29	12.44
3- Olive tree**	17.5	14.37	14.01
4- Half-moon**	20.65	20.18	18.96
5- Grazing *	10.85	7.66	7.2
6- Control Half-moon**	19.14	18.80	16.46
7- Control v-shape**	20.1	18.19	20.5

*: At 15 cm soil depth, ** At 30 cm soil depth.

Table (5) amount of accumulative sedimentation in 2003/2004 winter season.

Dura site		**Sorif site**		**BaniNo'em site**	
Treatments	Sedimentation **Kg/50m^2**	Treatments	Sedimentation **Kg/50m^2**	Treatments	Sedimentation **Kg/50m^2**
Olive Tree	0.6908	**olive tree**	0.3029	**Na.veget**	0.637
Stone terracing	0.465	**shrubs**	0.7961	**Terracing**	-------
Na.veget	0.4165	**terracing**	1.2812	**Tree**	0.116
		Na. veget	1.226	**soil terracing**	0.602
		hafmoon	1.57		

Table (6) some primary results of soil characteristics in Sorif site during 2003/2004 season

Treatments	**pH**	**EC (dSm^{-1}) (1:2.5)**	**CaCO3 %**	**Soil Texture**			
				% coars sand	**%Fine San y**	**%Silt**	**%clay**
olive tree	7.7	0.33	63.6	19.8	12.2	23.9	44.1
Shrubs	7.13	0.54	20.4	1.1	14.8	26.9	57.2
terracing	7.4	0.46	20	4.2	10.9	25.3	59.6
Na. veget	7.2	0.42	23.1	1.2	17.4	10.7	70.6
halfmoon	7.3	0.48	37.7	13.2	21.2	7.6	58.0
Grazing	7.4	0.49	52.4	25.1	14.1	24.4	36.3

Table (7) some primary results of soil characteristics in **Dura** site during 2003/2004 season .

Treatments	**pH**	**EC (dSm^{-1}) (1:2.5)**	**CaCO3 %**	**Soil Texture**			
				% coars sand	**%Fine San y**	**%Silt**	**%clay**
Olive Tree	7.8	0.24	35.2	4.8	34.5	27.5	33.3
Stone terracing	7.6	0.40	40	15.3	17.6	26.7	40.4
Na.veget	7.7	0.34	34.5	7.7	31.0	23.2	38.0
Halfmoon	7.8	0.29	28	7	32.5	29.3	31.2
Grazing	7.4	0.39	42	7.4	31.9	24.1	36.6

Table (8) some primary results of soil characteristics in **Bani No'em** site during 2003/2004 season.

Treatments	pH	EC (dSm^{-1}) (1:2.5)	CaCO3 %	Soil Texture			
				% coars sand	%Fine San y	%Silt	%clay
Tree(acacia)	7.4	0.39	26.3	9.6	29.9	2.5	58.0
Stone terracing	7.6	0.36	35.5	6.7	14.4	18.2	60.7
Na.veget	7.7	0.36	31.4	6.3	28.3	11.9	50.1
Contour rig	7.7	0.33	33	3.7	33.4	16.4	46.5
Grazing	7.8	0.38	38.7	11.8	36.1	2.0	50.2

Middle East Watershed Monitoring and Evaluation Project-
USAID MERC Grant
Final Meeting
Cyprus Oct 1 to 3, 2005

Meeting Objectives

- Summarize accomplishments/progress to date of the project (not necessarily assess results).
- Assess whether we have the information needed to address the three questions that we initially set out to answer in the project.
- Define next steps and concrete actions to finalize the project based on our assessment of progress.
- Define structure, next steps, deadlines and responsibilities to prepare final report.
- Reflect on lessons and benefits of the project (e.g. Palestinian training in Israel).
- Explore long term sustainability of the project (what is the utility of the work each country is doing, e.g.: dissemination of the project results and collaborative publication opportunities).

Agenda

October 1st - Day One
Reconnecting - Discovering Project Accomplishments

Morning **10:00 a.m. to 12:30 p.m.**	**Afternoon** **13:30 to 15:30 p.m.**
Welcome *Jenniffer Peterson and Chuck Troendle* **Start Up Activity** *Patricia Garcia* **Meeting Objectives, Agenda, Expectations, guidelines for working together** *Patricia Garcia* **New Chair** *Chuck Troendle* **Photo show, gallery walk** *Patricia Garcia*	**Monitoring and Evaluation of Watersheds in the Middle East Region - Project Review** Session Objectives: 1. Identify project accomplishments 2. Identify activities not included 3. Get agreement that final conclusions/activities discussed represent project participants' work 4. Gather information needed for final report or identify information gaps. Session design: • Project objectives – Reflection • Project Presentation *By Chuck Troendle* • Group Discussions

Middle East Watershed Monitoring and Evaluation Project-
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October 2nd - Day Two
Project Problem Solving, Final Report and Learnings

<table>
<tr><th><u>Morning</u>
<u>9:00 to 12:30 a.m.</u></th><th><u>Afternoon</u>
<u>13:30 p.m. to 15:30 p.m.</u></th></tr>
<tr><td>
Day Start up

How to Solve project Issues identified during yesterday's session

<u>Session Objectives:</u>
1. Review information and issues identified yesterday
2. Analyze country contribution to solve identified issues
3. Strategize on ways to acquire information or achieve missing project outputs

<u>Session Design:</u>
<u>Part 1</u>
• Small group reflection by Country
• Plenary

<u>Part 2:</u>
• Thematic Group Discussion
• Plenary
</td><td>
Next Steps for Final Report

<u>Session Objectives:</u>
1. Achieve agreements and clear commitments to prepare the final report.
2. Agreed on key input needed.
3. Provide our version of USAID reporting requirements.

<u>Session Design:</u>
• Presentation about final report structure and deadlines.
Chuck Troendle and Jennifer Peterson
• Questions and answers

Project Learnings and Benefits

• Students' 15 minute presentations on their theses
• Questions and answers after each presentation.
</td></tr>
</table>

Middle East Watershed Monitoring and Evaluation Project-
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October 3rd - Day Three
Project Learnings and Benefits

<table>
<tr><th><u>Morning</u>
<u>9:00 a.m. to 12:30 p.m.</u></th><th><u>Afternoon</u>
<u>13:30 p.m. to 15:00 p.m.</u></th></tr>
<tr><td>
Day Start Up

Project Learnings and Benefits

<u>Session Objectives:</u>
1. Identify concrete learnings / benefits for participants. Concrete experiences/examples.
2. Identify concrete demonstrations of collaboration (how meeting others affected their country activities)

<u>Session Design:</u>
• Group reflections.
• Plenary

Exploring Long Term Sustainability

<u>Session Objectives:</u>
1. Define plans to disseminate project results.
2. Identify ideas/plans to continue using/monitoring sites – Financial plans
3. Identify plans to offer managers an evaluation of the techniques tested in the study

<u>Session Design:</u>
• Small groups discussion
• Plenary
</td><td>
Closing:

Review of meeting accomplishments and conclusions
Definition of Next Steps
Acknowledgements and Celebrations
Final expressions – Chuck and others
Closing
</td></tr>
</table>

Dear Ariel
Hi, Including is the main subjects for a suggested training course, these subjects come as a result of the communication between my students and the student at Sede Boqer, and according to their needs. And their will be tow students sharing in this training.

I hope that it will be suitable for you so we can start arranging for the course and if their is any suggestion please send it to me.

Best regards

Ayed Salama

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Suggested training course:

* Laboratory works, to measure some soil properties as:
- Soil aggregate stability
- Soil structure
- Bulk density.
- Other analysis important to soil erosion and runoff.

* Filed works,
- Practices to measure some important soil characteristics in the field as;
  - Soil classification.
  - Profile description
  - Measure soil properties related to soil erosion and runoff.

* Practices on instruments that used to measure: infiltration rate, hydraulic conductivity, soil moisture, and others measurements.

* Works with student
(Dr. Masae , (student)) , she specialist in soil science , and Allony who work on water harvesting and soil moisture, and Professor Pedro to discus with him some points related to some measurements and the best way to use these data on right way on thesis.